Australian Government
Department of Innovation
Industry, Science and Research

Australian **Innovation System** Report 2010

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INNOVATION

Australian Government

Department of Innovation
Industry, Science and Research

Australian Innovation System Report 2010

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FOREWORD

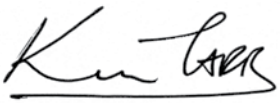
Australia needs an effective innovation system if it is to maintain living standards and provide good jobs for all. In a world full of low-cost producers, we cannot win business on price alone; we have to do it by being more creative and more productive. We also rely on our innovation system to answer the many other great challenges of our time, from repairing the environment, to curing disease, to enriching community life.

In May 2009, the Australian Government released *Powering Ideas: An Innovation Agenda for the 21st Century*, which outlined its plans to revitalise Australia's innovation system over the next decade. We supported this agenda with a $3.1 billion increase in funding for research and innovation over four years. *Powering Ideas* sets out the Australian Government's priorities and targets for the national innovation system. It describes the policy and program directions the Australian Government will take to achieve its goals, with the focus on skills and research capacity, business innovation, links and collaboration and public sector innovation.

In *Powering Ideas*, the Australian Government promised to produce an annual report on innovation. The *Australian Innovation System Report 2010* is the first of these.

It establishes a baseline for the performance of the system against the priorities and targets in *Powering Ideas.* The report describes both what has been achieved over the last two years, and the forward plans of various participants in the national innovation system, including governments, public sector researchers, and industry. It also identifies things we need to get better at – measuring innovation, predicting technology trends, and recruiting people to the research workforce.

We have made a great start, but there is still much more to be done.



Senator Kim Carr
Minister for Innovation, Industry,
Science and Research

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EXECUTIVE SUMMARY

Innovation is a primary driver of sustainable productivity growth and social wellbeing. Conscious of this, in May 2009 the Australian Government set out a ten-year vision for strengthening innovation and increasing productivity in *Powering Ideas: An Innovation Agenda for the 21st Century*.

Part of that strategy, which is supported by an increase of almost 25 per cent in science and innovation investment in 2009-10 over the previous year, is a new series of annual reports on the performance of Australia's national innovation system. The *Australian Innovation System Report 2010* is the first of that series.

This report provides metrics and baseline indicators as a platform to compare Australia's innovation performance with other OECD countries and track progress against the Government's priorities and targets in the coming years. While it cites the most recent and comprehensive data available, most of this data dates back to 2007-08 or earlier. Our understanding of recent developments must depend on more qualitative evidence until new metrics become available in the years ahead. This data gap is a global problem and the report itself discusses national and international efforts to develop more timely and sensitive metrics of innovation performance. Notwithstanding these limitations, the data available can still serve as a yardstick against which efforts to meet the priorities and targets in *Powering Ideas* can be measured in the future. Each chapter also provides case studies of world-class innovation achievements by Australian researchers, businesses, and governments.

The Australian innovation system: key features and trends

The Australian innovation system is an open network of organisations interacting to produce and use new knowledge and technology to create economic and social value.

Some features of Australia's innovation system and performance include:

- Innovation drives productivity improvements, and hence economic growth. Sixty-five per cent of economic growth per capita in Australia over the last four decades can be attributed to increases in multi-factor productivity (MFP). Nevertheless, Australia's MFP growth over the long term is slightly below the median of nineteen OECD countries.
- Australia's gross expenditure on research and development (GERD) has grown consistently over the last few decades, and a significant amount of this is due to business investment in R&D. GERD has grown at an annual rate of 6.1 per cent over the last twenty-two years in real terms, and businesses contributed two-thirds of the absolute GERD increase over this period.
- In 2007-08 the number of innovating firms increased to 39.1 per cent, up 6.4 percentage points from 2006-07. In 2007-08, the top three innovation sectors were wholesale trade, retail trade and manufacturing, with 51.4 per cent, 50.9 per cent and 45.6 per cent of businesses in those sectors innovating.
- The Australian innovation system consistently underperforms on most measures of collaboration and networking; however, disaggregated data by firm size, sector and type of collaborator reveals marked differences. For example, while 84 per cent of innovation-active businesses had no collaborative arrangements in 2006-07, 60 per cent of large innovation-active mining firms undertook collaboration.
- Information technology, marketing and business management were the most frequent skills used for innovation. The largest shortage of skills required for innovation was in the trades professions. Considerable differences in skills needs arise when data is analysed by industry sector or firm size.

- Eco-innovation is an important driver of renewal in the innovation system. Low-carbon and renewable-energy innovation received 32 per cent or $1.05 billion of the grant funding allocated for science and innovation programs in the 2009-10 Commonwealth Budget, an increase of 290 per cent from the previous year.[1]

Research capacity and skill base

Australia's innovation performance is underpinned by its research capacity and skills base. Research in the public and private sectors creates new ideas which fuel innovation, while skilled workers drive innovation by turning ideas into new products, services and processes for the benefit of the economy and society.

In *Powering Ideas*, the Australian Government set priorities and targets for improving Australia's research capacity and skill base:

Priority 1: Public research funding supports high-quality research that addresses national challenges and opens up new opportunities.

Target: The Australian Government's ambition is to increase the number of research groups performing at world-class levels, as measured by international performance benchmarks.

Priority 2: Australia has a strong base of skilled researchers to support the national research effort in both the public and private sectors.

Target: The Australian Government's objective is to significantly increase the number of students completing higher degrees by research over the next decade.

In respect of research capacity, the number of research fields with higher than world average citations is applied as a proxy indicator of progress against the Government's target to increase the number of research groups performing at world-class levels.

Over the period 2004-08, Australia recorded higher than world average citation rates by field in nineteen out of twenty-two research fields.

As for higher degree completions, in 2008, 7,478 students completed a higher degree by research in Australia. This provides a baseline for the Government's target to significantly increase the number of students completing higher degrees by research over the next decade.

Australia is placed in the top third of OECD countries in terms of R&D expenditure in the public sector and number of scientific publications.[2] On the other hand, Australia ranks only in the middle third on GERD relative to GDP and population, and on the quality of its scientific publications.

With regard to skill base, Australia is among the top third of OECD countries in terms of gross investment in tertiary education, population with a tertiary qualification, new PhDs, and professionals and technicians in total employment. Australia's performance is moderate however, when compared to other OECD countries on indicators of public investment in tertiary education, new graduates with science and engineering qualifications, R&D personnel as a proportion of total employment, and researchers as a proportion of the labour force.

The Australian Government has strengthened its efforts to support high-quality public research and build a strong base of skilled researchers. Major initiatives have been implemented to improve research quality and accountability in the higher education sector, to increase investment in research infrastructure, to boost funding for research training, and to support researchers at different stages of their careers. State and territory governments have also made significant contributions to strengthening Australia's research capacity and skill base through funding for high-impact research facilities, initiatives to create knowledge hubs, and support for talented researchers.

Business innovation

Technological innovation by businesses involves the creation of new knowledge that leads to the development of a product or service; it also includes process innovation which leads to improved production or delivery methods. Non-technological innovation covers changes in organisational and managerial processes to improve a firm's performance or efficiency. In *Powering Ideas*, the Australian Government set the following priorities and targets for innovation in business:

1 The total of $1.05 billion includes all programs related to low-carbon and renewable-energy innovation listed in Table 3 of the *Australian Government's 2009-10 Science and Innovation Budget tables.*

2 R&D expenditure in the public sector is composed of higher education expenditure on R&D (HERD) and government expenditure on R&D (GOVERD).

Priority 3: The innovation system fosters industries of the future, securing value from the commercialisation of Australian research and development.

Target: The Australian Government aims to see a continuing increase in the number of businesses investing in R&D.

Priority 4: More effective dissemination of new technologies, processes, and ideas increases innovation across the economy, with a particular focus on small and medium-sized enterprises.

Target: The Australian Government's goal is to achieve a 25 per cent increase in the proportion of businesses engaging in innovation over the next decade.

The number of companies registered for the R&D Tax Concession is a primary indicator of progress against the Government's target of a continuing increase in the number of businesses investing in R&D. In 2007-08, 7,754 businesses were registered for the R&D Tax Concession, providing a baseline for that target. The proportion of innovation-active businesses provides a measure of progress against the Government's target of achieving a 25 per cent increase in the proportion of businesses engaging in innovation over the next decade. In 2007-08 innovation-active businesses accounted for 44.9 per cent of all businesses in Australia.

Australia ranks in the middle third of OECD countries on most indicators of innovation activities, including business expenditure on research and development (BERD), generosity of tax treatment for business R&D, patenting and non-technological innovation. Australia is relatively lowly ranked on the proportion of firms that develop product innovations which are new to the market.

With respect to innovation outputs and outcomes, Australia is in the top third of OECD countries for knowledge-intensive market services, GDP per capita, and human development, and in the middle third on indicators of labour productivity and global competitiveness. On measures of high and medium-high technology manufacturing, high-technology manufacturing exports, and environment performance, Australia is ranked in the bottom third.

To foster industries of the future in Australia and increase support to innovative firms, the Australian Government will replace the existing *R&D Tax Concession* with a new, streamlined *R&D Tax Credit*. The Government is providing commercialisation assistance and driving eco-innovation through a number of new initiatives (including Clean Business Australia, Commercialisation Australia and the Clean Energy Initiative). It is acting to increase innovation across the economy by improving business access to ideas, technologies and venture capital, improving the intellectual property (IP) system, and fostering an innovation culture in industry. State and territory governments have also introduced initiatives to support the development of new products, services, processes and business models through the provision of venture capital, commercialisation services and business advice.

Links and collaboration

Collaboration and networking between industry and the research community enables business to tap into ideas and expertise to resolve ongoing challenges, create new products and services, and become more competitive and profitable. Collaboration within the research community enables us to build capacities that are greater than the sum of their parts. International collaboration gives Australian researchers and scientists access to new knowledge and opportunities to leverage domestic investments in research and infrastructure.

In *Powering Ideas*, the Australian Government set priorities and targets for links and collaboration:

Priority 5: The innovation system encourages a culture of collaboration within the research sector and between researchers and industry.

Target: The Australian Government's ambition is to double the level of collaboration between Australian businesses, universities and publicly-funded research agencies over the next decade.

Priority 6: Australian researchers and businesses are involved in more international collaborations on research and development.

Target: The Australian Government has adopted the long-term aim of increasing international collaboration in research by Australian universities.

The proportion of innovation-active businesses collaborating with universities and public research agencies is a measure of progress against the Government's target to double the level of collaboration between Australian businesses, universities and publicly funded research agencies (PFRAs) over the next decade. In 2006-07 around 1.6 per cent of innovation-active businesses collaborated with universities and 7.2 per cent collaborated with PFRAs.

The share of university R&D financed from abroad and the number of formal agreements on academic and research collaboration between Australian universities and overseas institutions are primary indicators of progress against the Government's target of increasing international collaboration in research by Australian universities. In 2006, around 2.9 per cent of higher education expenditure on research and development (HERD) was financed from abroad, and there were 3,493 formal agreements on research collaboration between Australian universities and overseas institutions in 2009.

With regard to knowledge exchange, Australia is in the top half of OECD countries for business-financed R&D performed by universities and government agencies (business-financed HERD and government expenditure on research and development) and patents owned by universities and government agencies. Australia ranks in the mid-range of OECD countries in terms of small and medium enterprises collaborating in innovation with higher education institutions and government institutions. For large firms, Australia ranked towards the bottom of the group of OECD countries on innovation collaboration with higher education institutions and government institutions.

On global integration, compared to other OECD countries, Australia has a relatively low rate of international collaboration on R&D and innovation measured by gross expenditure on R&D financed abroad, co-authored scientific publications, patents with foreign co-inventors, total international technology payments and receipts, and firms involved in foreign cooperation on innovation.

In contrast, Australia records one of the highest inflows of human capital from overseas among OECD countries, measured by the proportion of foreign-born people in the total employed population having a tertiary qualification (second highest in the OECD). Australia also has the sixth highest proportion of international students enrolled in advanced research programs among OECD countries.

The Australian Government supports collaboration between Australian researchers and their counterparts at home and abroad, and between researchers and industry through a wide range of programs. The Government has explicitly internationalised research programs to promote the transfer of skills and the dissemination of new ideas and technologies. The new R&D Tax Credit will be available to foreign firms and firms conducting R&D activities for which the intellectual property rights are held offshore.

State and territory governments also fund initiatives and partnerships to support public and private sector collaboration and international collaboration. These projects build national and international industry partnerships and research collaborations that provide opportunities for each state in the development of new skills, industry capabilities or research capacity.

Public sector innovation

The public sector accounts for approximately 29 per cent of GDP in Australia. Improving policy and program development through innovation is therefore a priority for the Government. Public sector innovation involves the "creation and implementation of new processes, products, services, and methods of delivery which result in significant improvements in the efficiency, effectiveness or quality of outcomes". [3]
In *Powering Ideas*, the Australian Government set the following priority:

Priority 7: The public and community sectors work with others in the innovation system to improve policy development and service delivery.

The Government has a multi-pronged approach to improving public sector innovation.

- The Review of the Australian Government Administration includes a focus on public sector innovation.
- The Australian Public Service Management Advisory Committee has undertaken a cross-agency project to examine how innovation can be encouraged in the public sector and to identify issues inhibiting innovation in the public sector.
- The Australian National Audit Office has released a *Better Practice Guide to Innovation in the Public Sector* to provide a practical framework to assist public sector agencies in their management of innovation, and to further promote an innovation culture within the public sector.
- The Government 2.0 Taskforce has identified the use of collaborative tools and approaches in *Engage: Getting on with Government 2.0*, to achieve a more open, accountable, responsive and efficient government.

3 Mulgan, G and Albury, D (2003), *Innovation in the Public Sector*, Cabinet Office Strategy Unit, London.

- The Australian Centre of Excellence for Local Government, supported by the Australian Government, aims to increase professionalism, showcase innovation and build research and development capacity to achieve better policy formulation.
- The development of metrics and data collection on public sector innovation is critical to benchmarking Australia's performance against other OECD countries and monitoring progress against the Government's goals. Australia is a member of the OECD taskforce which is examining options for measurement in this area.

This report illustrates a number of achievements and actions from the Australian Government and state and territory governments to promote innovation in the public sector.

Opportunities and challenges

In a 21st century characterised by increasing global economic competition, rapid development of knowledge and technology, and pressing social and environmental issues, Australia must continuously address these opportunities and challenges to create a more effective and efficient national innovation system.

In *Powering Ideas*, the Australian Government signalled several initiatives to support a more innovative Australia, including implementing a new foresight model, producing a research workforce strategy, and developing a measurement and analytical framework for the Australian innovation system.

The Prime Minister's Science, Engineering and Innovation Council (PMSEIC) has adopted a new model incorporating foresight methodology to support long-term, whole-of-government policy development. PMSEIC's foresighting aims to identify gaps in evidence and activity to inform decision-makers of potential future impacts of current choices and focus policy engagement with future challenges. The methodology outlines possible futures and assists in developing a strategy to reach a preferred future by systematically examining the longer-term future of science, technology, the economy, the environment and society.

Australia's research workforce is a crucial part of our skills base. Australia must therefore focus on maintaining the quality and reach of its research training system, meeting research workforce needs and building attractive career pathways for its researchers. The Research Workforce Strategy will explore and address potential shortfalls in the future supply of research-qualified people in Australia. It will also support Australia in meeting the targets for the national innovation system outlined in *Powering Ideas*. Work on the strategy is expected to be completed in the second half of 2010.

Understanding the dynamics of the innovation process is important in determining the effectiveness of government expenditure on innovation and improving policy coordination across government. In 2009, the Government commissioned the development of a measurement and analytical framework for the national innovation system. The Innovation Metrics Framework aims to develop guidelines for innovation measurement and program data collection and analysis. It evaluates limitations of current measures, identifies principles for developing new indicators and determines methods for achieving consistent program data collection.

INNOVATION SYSTEM PERFORMANCE INDICATORS

The indicators highlighted in orange will directly measure progress against the Australian Government's *Powering Ideas* innovation targets.

Research capacity and skill base

Indicators	Latest Figure	Reference Year	OECD Ranking	Gap from the Top Five OECD Performers
Target 1: Increase the number of research groups performing at world class levels				
Target 2: Increase the number of students completing higher degrees by research over the next decade				
Number of fields with higher than world average citation rate by field	19 out of 22 fields	2004-08		*Target 1 & 2*
Number of students completing higher degree by research in Australia	7,478	2008		
HERD as a % of GDP	0.52%	2006	9th	24.6%
Publications per thousand researchers	413.8	2008	9th	31.2%
Public expenditure on tertiary education as a % of GDP	1.13%	2006	15th	43.2%

Business innovation

Indicators	Latest Figure	Reference Year	OECD Ranking	Gap from the Top Five OECD Performers
Target 3: Increase in the number of businesses investing in R&D				
Target 4: 25 per cent increase in the proportion of businesses engaging in innovation over the next decade				
Number of businesses registered for the R&D Tax Concession	7,754	2007-08		*Target 3 & 4*
Proportion of innovation-active businesses in Australia	44.9%	2007-08		
BERD as a % of GDP	1.27%	2007	14th	51.8%
Patent applications filed under PCT per million population	66.9	2007	15th	64.3%
Total investment in early stage venture capital as a % of GDP	0.054%	2008-09	-	-
Proportion of non-technological innovators in manufacturing sector	31.7%	2004-06	15th	47.1%
Proportion of non-technological innovators in services sector	28.2%	2004-06	17th	52.7%

Links and Collaboration

Indicators	Latest Figure	Reference Year	OECD Ranking	Gap from the Top Five OECD Performers
Target 5: Double the level of collaboration between Australian businesses, universities and publicly funded research agencies over the next decade				
Target 6: Increasing international collaboration in research by Australian universities				
Proportion of innovation-active businesses collaborating with publicly funded research agencies	**7.2%**	**2006-07**		*Target 5*
Proportion of innovation-active businesses collaborating with universities	**1.6%**	**2006-07**		
Number of formal agreements on academic/ research collaboration between Australian universities and overseas institutions	**3,493**	**2009**		*Target 6*
Share of HERD financed from abroad	**2.9%**	**2006**		
Proportion of Australian Science & Engineering publications co-authored with foreigners	38.9%	2003	25th	34.1%
Proportion of SMEs collaborating in innovation with higher education institutions	3.1%	2004-06	13th	62.6%
Proportion of large firms collaborating in innovation with higher education institutions	10.0%	2004-06	20th	75.8%

INTRODUCTION

The role of innovation

Innovation is the implementation of new or significantly improved products (goods or services), operational processes, marketing methods or organisational methods in business practice, workplace organisation or external relations.[4] Innovation occurs when people and organisations, while pursuing their own goals, also produce, spread, absorb and use knowledge and technology to generate economic, social and environmental value.

Innovation is a key enabler for Australians as we work to overcome challenges and realise opportunities in the coming decades. New technologies, products, services, and ways of working and organising will help Australia to address social and environmental challenges, raise productivity, and create new sources of wealth. As the Australian Government recognised in *Powering Ideas*, "Innovation is the key to making Australia more productive and more competitive. It is the key to answering the challenge of climate change, the challenge of national security, the age-old challenges of disease and want. It is the key to creating a future that is better than the past."[5]

The objective and structure of this report

In *Powering Ideas*, the Australian Government committed to produce annual reports on the impact of Australian innovation and the performance of the Australian innovation system as a whole. *The Australian Innovation System Report 2010* is the first of these reports, which will evolve over time to incorporate suggestions from stakeholders.

This report outlines features and trends of the Australian innovation system as a whole and highlights baseline performance under the four policy headings identified in *Powering Ideas*: skills and research capacity; business innovation; links and collaboration; and public sector innovation. The metrics and baselines included in the report will be used to measure and monitor the progress of the national innovation system against the Government's priorities and targets in coming years.

This report also highlights recent achievements and actions by national innovation system participants, focusing on those contributing to the National Innovation Priorities and the Government's innovation targets. It covers programs and initiatives by the Commonwealth, state and territory governments, plus case studies from businesses, universities and publicly funded research agencies. In the interests of brevity it offers a showcase rather than a comprehensive itemisation of actions and achievements that have contributed to building an effective innovation system. It also provides three topical papers outlining opportunities and challenges in innovation measurement, technology foresight and the research workforce.

The report covers the performance of the national innovation system as a whole using existing data sets. Data on Australia's innovation performance since the release of *Powering Ideas* is not yet available. The data predates the Government's recent investment in science and innovation – $8.6 billion in 2009-10 – and recent initiatives by other participants in the national innovation system. Nevertheless, the report is structured around the *Powering Ideas* priorities and targets, and future editions will measure Australia's performance against those goals as data becomes available.

The Australian innovation system

Innovation is undertaken by people and organisations pursuing their respective goals and performing the highly interdependent functions of an innovation system: producing, absorbing, using and diffusing knowledge and technology to gain economic and social value.

This report concerns itself with Australia's *national innovation system* in its entirety. It considers participants from all states and territories and all economic sectors, including the public sector.

The national innovation system is an open network of organisations interacting with each other in an environment that stimulates and regulates their activities and interactions.

4 Organisation for Economic Co-operation and Development (OECD) (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd edition, OECD. This manual has been developed jointly by Eurostat and the OECD to aid in measuring the process of innovation.

5 Australian Government (2009), *Powering Ideas: An Innovation Agenda for the 21st Century*, Commonwealth of Australia, Canberra, p. 1.

The three main components of the Australian innovation system – organisations (including individuals), interactions and environment – collectively function to produce and diffuse innovations that have economic, social and/or environmental value.

Organisations in the innovation system include businesses, universities, publicly funded research organisations (PFROs) and Commonwealth, state and territory governments.[6] These are supported by education, finance, infrastructure and intermediary organisations that facilitate networks of interaction, provide financial and human capital, and especially coordinate knowledge producers with the demands of innovating organisations.

All organisations interact with each other in the process of creating and diffusing innovations. Each link connects organisations in the innovation system, providing sources of knowledge and other resources for innovation activity. Links can be described by the intensity of interaction, ranging from passive, open sources of information, to cooperative, collaborative and joint partnerships. Links can also range in character from market-based transactions such as competition and trade, to social exchanges such as sharing information through networking.

All participants operate in an environment shaped by the culture and broader political economy, which influences the scale, direction and relative success of all innovative activities. The environment of the Australian innovation system comprises sets of common habits, routines, established practices, rules or laws that regulate the interactions between individuals and organisations.

Global context

Extensive and complex as the Australian innovation system is, it is a sub-system embedded in Australia's national economy and society which, in turn, is strongly affected by the globalised economy and society.

Australia has an open economy, allowing the international trade of goods and services (and its financing) to proceed with relatively little interference. Despite this openness, Australia has a lower level of trade dependence than most other advanced economies. Australia's major exports are minerals, particularly coal and iron ore, education services and tourism; its imports are dominated by tourism and personal recreational services along with petroleum and capital equipment. About 70 per cent of Australia's trade is currently with the member economies of the Asia-Pacific Economic Cooperation forum which includes seven of Australia's top ten trading partners, and four of the top five – China, Japan, the USA and Korea.[7]

In the medium to long term, economic competition and structural changes triggered by the rise of China and India are set to change the landscape of the world economy. According to an OECD report, China has the potential to overtake the USA to become the leading producer of manufactured goods in the next five to seven years.[8] In addition, China has significantly increased investment in science and research. Similarly, India, presently Australia's eighth largest trading partner, will continue to expand its activities in industrial and services sectors. India is also projected to experience an increase in the working-age share of the population, boosting its labour force. This is in stark contrast to the projected declines in the working-age population of most developed nations and other Asian economies.

The rapid industrialisation of the world's most populous countries has accelerated the globalisation of innovation, adding new dimensions to the challenges facing policy makers in individual nations. China and India have become popular destinations for offshoring of research and development (R&D) and related high-skill jobs previously performed in mature industrialised economies. This migration of investment and dispersal of the value-chain risks eroding existing national R&D infrastructures and capacities.[9] For a country with a relatively small population such as Australia, which produces just 2 per cent of the world's research, it is imperative for the national innovation system's performance (and hence productivity) to access and harness the vast knowledge generated by the rest of the world. The ability to adequately manage this challenge involves, in a large part, success in the growing global competition for skilled people.

6 For the purposes of this report, publicly funded research organisations (PFROs) includes publicly funded research agencies (e.g. CSIRO and ANSTO), medical research institutes and what are internationally referred to as government research institutions. PFROs do not include universities.

7 Department of Foreign Affairs and Trade (2009), *Composition of Trade Australia 2008-09*, Canberra, p.29.

8 OECD (2010), *China: OECD Economic Survey 2010*, vol. 2010/6, 2 February 2010, OECD, Paris, p. 24.

9 OECD and the World Bank (2009), *Innovation and Growth: Chasing a Moving Frontier*, OECD, Paris.

In late 2008, the global financial crisis (GFC) ended six years of above-average world economic growth during which Australia's annual economic growth averaged 3.4 per cent, exceeding the advanced economies' average of 2.5 per cent.[10] The GFC was the catalyst for the worst recession in over fifty years, causing most countries to experience negative growth during 2008-09. Output in the world's advanced economies fell an estimated 3.2 per cent in 2009, while Australia's output increased 0.7 per cent.[11] National governments, including Australia's, responded to the crisis with immediate fiscal stimulus packages and easing of monetary policies to support domestic demand and assist in loosening access to finance. By early 2010, there were signs that a tentative, uneven recovery was under way, with the IMF predicting "the recovery in advanced economies is still expected to be weak by historical standards, with real output remaining below its pre-crisis level until late 2011."[12] Governments have thus moved to accelerate structural change, with a long-term aim of building a sustainable future.

Challenges and opportunities for Australia

Australia fared significantly better through the GFC than any other developed country, avoiding recession and keeping unemployment growth below the OECD average and previous historical trends. This resilience was assisted by a number of factors, including Australia's strong exports to high growth economies, the strength of the financial services sector, and the Australian Government's fiscal stimulus strategy. Nevertheless, Australia, like many countries, still faces challenges to increase productivity with the long-term goal of sustainable economic growth and prosperity.

Climate change and Australia's ageing population pose new and emerging challenges on the road to raising Australia's economic productivity, as the economy and aspects of society undergo significant restructuring.[13] But challenges of this type and magnitude also present opportunities to advance Australia's economic development.

Australia's proximity to the dynamic Asia-Pacific region is likely to provide opportunities to expand commodity exports and offer value-adding products and services. In this, Australia may be able to harness the power yet to be unleashed by breakthroughs in information and communication technology.

OECD Innovation Strategy

In 2007, OECD Ministers called upon the organisation to develop a strategy to strengthen the contribution of innovation to economic and social objectives. The OECD *Innovation Strategy* seeks to harness innovation for stronger and more sustainable growth and development, and to help address increasingly urgent global issues such as climate change, health, food security and poverty that depend on stronger innovation and new forms of international collaboration.

Development of the Innovation Strategy is now entering its final stages and it will be presented to Ministers in 2010 at the annual OECD Ministerial Council Meeting. It will deliver a set of high-level policy principles which are broad and flexible and which can be tailored to country circumstances: the level of economic development, economic structure and institutional setting. These broad principles will be complemented with more detailed analysis and policy guidance that can help underpin the development and implementation of effective, whole-of-government policies for innovation in the 21st century.

The Innovation Strategy adopts a broad, system-wide approach to fostering innovation and emphasises the importance of a strategic approach to enhancing innovation for achieving public policy objectives. Policy coherence, developing strong human capital, collaboration in an interconnected global economy and the matching of the supply of knowledge and innovation to market demands by firms, households and individuals are challenges facing countries as they seek to elevate innovation into mainstream economic policy.

The Innovation Strategy is expected to lead to a number of outputs including the production of a compendium of indicators, a *Policy Handbook* and a series of thematic documents to provide operational advice and guidance to countries on implementing the strategy. It will also contribute to the development of the OECD's ongoing work including the *Green Growth* and *Measuring the Progress of Societies* projects.

Australia has contributed heavily to the development of the strategy, including by hosting a two-day discussion roundtable in February 2010. This contribution recognises the extensive knowledge underpinning the strategy, knowledge that can be used in the design and implementation of future innovation initiatives in Australia.

10 International Monetary Fund (IMF) (2009), *World Economic Outlook* database, viewed 15 March 2010, http://www.imf.org/external/datamapper/index.php. The IMF's 33 advanced economies include all OECD countries (except Mexico) and Cyprus, Israel and Malta.

11 IMF (2010), *World Economic Outlook* Update, 26 January 2010.

12 IMF (2010), *World Economic Outlook* Update, 26 January 2010, p. 3.

13 Henry, K (2009), 'The shape of things to come: long run forces affecting the Australian economy in coming decades', speech to Business Leaders' Forum, Queensland University of Technology, 22 October 2009.

A common theme which runs through all aspects of the Innovation Strategy is measurement, with a focus on a revitalised framework for the measurement of an expanded, more interconnected concept of innovation and its broader outcomes. The Innovation Strategy's measurements agenda builds systematically on five decades of indicator development and analyses at the OECD, particularly through the *Working Party of National Experts on Science and Technology Indicators*, the analytical work of the *Working Party on Industry Analysis*, and the *OECD Blue Sky Forum*.

Actions for advancing the measurement agenda include:

- improving the measurement of broader innovation and its links to macro-economic performance
- investing in a high-quality and comprehensive data infrastructure to measure impacts
- recognising the role of innovation in the public sector and promoting its measurement
- promoting the design of new statistical methods and interdisciplinary approaches to data collection
- promoting the measurement of innovation for social goals and of social impacts of innovation.

The Innovation Metrics Framework, completed in late 2009 aligns with this international innovation measurement agenda, and Australia will initially be focusing efforts on the first three actions above.

The Australian Government's innovation agenda

Following an extensive review of the national innovation system, the Australian Government announced *Powering Ideas: An Innovation Agenda for the 21st Century*, on 12 May 2009. *Powering Ideas* is a ten-year plan to strengthen Australia's national innovation system. It outlines a framework for increasing the effectiveness of Australia's innovation efforts and fostering future productivity improvements.

The Australian Government adopted seven National Innovation Priorities to focus the production, diffusion and application of new knowledge. These mark the optimal course for improving skills and expanding research capacity, increasing incentives for innovation in the business, government and research sectors, and building links and enhancing collaboration.

The seven National Innovation Priorities and their associated innovation targets are:

Priority 1: Public research funding supports high-quality research that addresses national challenges and opens up new opportunities.

Target: The Australian Government's ambition is to increase the number of research groups performing at world class levels, as measured by international performance benchmarks.

Priority 2: Australia has a strong base of skilled researchers to support the national research effort in both the public and private sectors.

Target: The Australian Government's objective is to significantly increase the number of students completing higher degrees by research over the next decade.

Priority 3: The innovation system fosters industries of the future, securing value from the commercialisation of Australian research and development.

Target: The Australian Government aims to see a continuing increase in the number of businesses investing in R&D.

Priority 4: More effective dissemination of new technologies, processes, and ideas increases innovation across the economy, with a particular focus on small and medium-sized enterprises.

Target: The Australian Government's goal is to achieve a 25 per cent increase in the proportion of businesses engaging in innovation over the next decade.

Priority 5: The innovation system encourages a culture of collaboration within the research sector and between researchers and industry.

Target: The Australian Government's ambition is to double the level of collaboration between Australian businesses, universities and publicly-funded research agencies over the next decade.

Priority 6: Australian researchers and businesses are involved in more international collaborations on research and development.

Target: The Australian Government has adopted the long-term aim of increasing international collaboration in research by Australian universities.

Priority 7: The public and community sectors work with others in the innovation system to improve policy development and service delivery.

Powering Ideas presents a range of actions the Australian Government has already undertaken to boost Australia's innovation system, as well as new proposals to address the system's weaknesses. For example, the Government has invested in research infrastructure through the Education Investment Fund and is developing a Research Workforce Strategy to ensure Australia's universities produce sufficient research graduates.

Powering Ideas also sets out a vision for various players in the national innovation system. By 2020, the Australian Government wants a national innovation system in which:

The Commonwealth clearly articulates national priorities and aspirations to make the best use of resources, drive change, and provide benchmarks against which to measure success

Universities and research organisations attract the best minds to conduct world-class research, fuelling the innovation system with new knowledge and ideas

Businesses of all sizes and in all sectors embrace innovation as the pathway to greater competitiveness, supported by government policies that minimise barriers and maximise opportunities for the commercialisation of new ideas and new technologies

Governments and community organisations consciously seek to improve policy development and service delivery through innovation

Researchers, businesses and governments work collaboratively to secure value from commercial innovation and to address national and global challenges.

The Australian Government's investment in research and innovation

The Australian Government has increased spending on research and innovation in recognition of the important role innovation plays in boosting productivity and international competitiveness, and nurturing emerging industries. Between 2008-09 and 2009-10, the Government's investment in science and innovation increased by almost 25 per cent – from $6.9 billion to $8.6 billion.

The 2009-10 Federal Budget included a $3.1 billion increase in funding over four years to support the Government's innovation agenda. The Budget provided more support for world-class university research, a Super Science Initiative focusing on national research strengths, a new R&D Tax Credit, Commercialisation Australia to facilitate commercialisation of Australia's best research, and other measures to boost business innovation.

The Australian Government, like many governments around the world, also used the GFC as an opportunity to invest in green recovery. Investment in green innovation will not only improve the environment, but also drive economic recovery and support high-wage, high-skill jobs. It allows Australia to create new industries and sustainable prosperity by capturing a share of the growing international market for carbon-cutting technologies. In the 2009-10 Budget, the Government provided over $4.8 billion for climate change initiatives and programs, bringing the Government's total investment in climate change initiatives to over $15 billion since 2008-09.

All these initiatives – and this report – are part of the Government's ongoing commitment to optimising the performance of Australia's innovation system.

CHAPTER ONE

The Australian innovation system: features and trends

As Australia's innovation system has evolved since the 1990s, so has our understanding of innovation systems. They are now best understood in terms of flows of knowledge and resources that facilitate innovation in an economy, rather than gross amounts of R&D expenditure.

The Australian innovation system no longer fits the description it had in 1990, when it was characterised by low levels of R&D expenditure, high levels of government involvement in financing and performing research, low levels of private sector R&D, and exceptionally high dependence on foreign technology.[14] Australia was then emerging from a long period of protection from international competition. Our national economy has since become increasingly open to trade and the flows of resources and knowledge that trade entails. In tandem with government policy reforms, this has driven increasing participation by the business sector in Australia's innovation system.

There is now a better understanding of Australia's unique industrial structure, which is characterised by large resource and services sectors, a smaller but high productive and resilient manufacturing base, and the high contribution of small and medium enterprises (SMEs) to the economy. More is now known of Australia's large service industry, which includes knowledge-intensive sectors where innovation is important but does not involve R&D. In recent years Australia's export-oriented resources sector has led the growth in business R&D expenditure and collaboration with universities. The diverse manufacturing sector has a well-linked medium-technology component that performs significant R&D and innovation, and excels in several market niches.

The Australian Government still maintains a considerable presence in the Australian innovation system, notably in its efforts to build capacity by educating and training the workforce. It also plays a key role in developing a strong knowledge base by funding research in universities and PFROs such as CSIRO, which are recognised for their world-class innovation performance.

Australia will face future challenges and opportunities arising from the economic dynamism of the Asia-Pacific region. Australia's innovation system will need to mobilise capabilities and creativity to transform these opportunities into real value in order to sustain economic growth and prosperity.

Features of the Australian innovation system

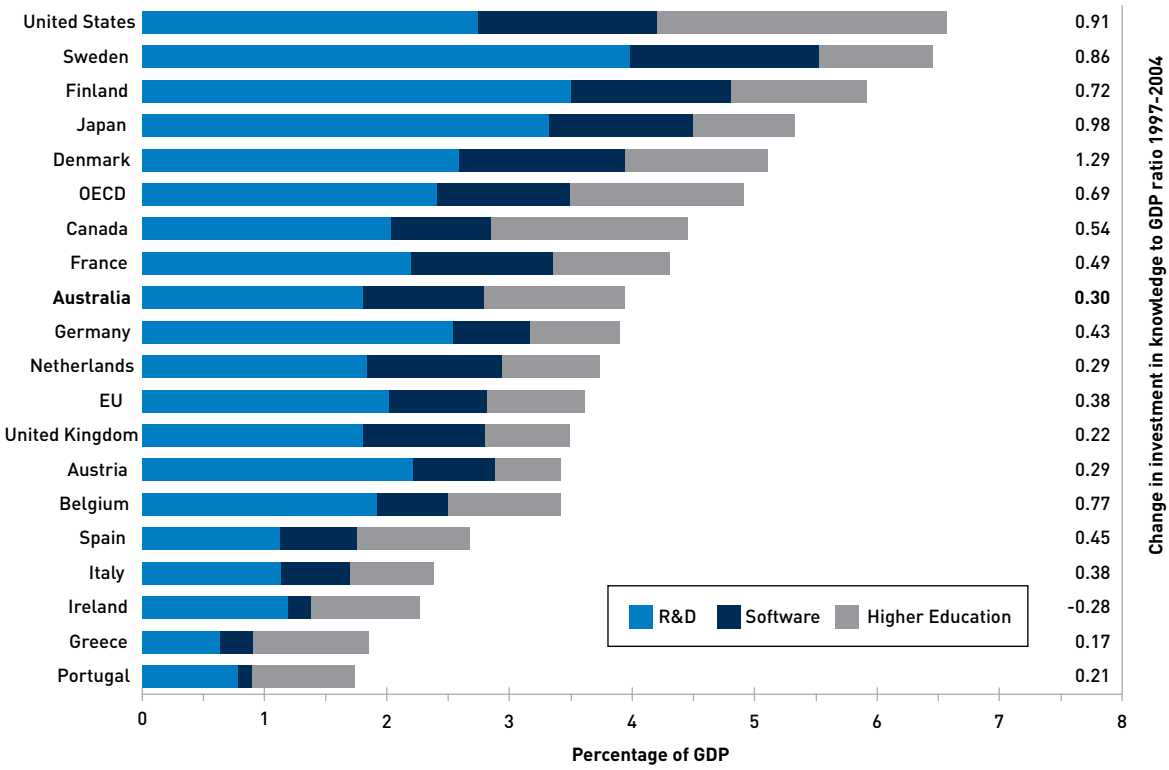
Investment in knowledge

Investment in knowledge is defined as the sum of expenditure on R&D, on higher education from both public and private sources, and on software. Investment in knowledge is a broad indicator of a country's progress in building innovation capacity; it tells us not only about technology creation and diffusion, but also about absorptive capacity and skills. Chart 1 shows Australia dedicated 3.9 per cent of its GDP to investment in knowledge, ranking eighth among eighteen OECD countries, but a percentage point behind the OECD average of 4.9 per cent.

The contributions of R&D, higher education and software to Australia's investment in knowledge were 1.8 per cent, 1.1 per cent and 1.0 per cent respectively. Corresponding percentages for the OECD average were all higher (2.4 per cent, 1.4 per cent, and 1.1 per cent). The change in investment in knowledge to GDP ratio over 1998-2003 was 0.30 percentage points, well under the 0.69 percentage points of the OECD average. Most of Australia's change in knowledge investment was attributed to R&D, followed by software. Investment in higher education as a percentage of GDP still ranked high (fourth among eighteen OECD countries).

14 Gregory, R.G (1993), 'The Australian Innovation System', in *National Innovation Systems: a comparative analysis*, Nelson R (ed), Oxford University Press, Oxford, p.324.

Chart 1: Investment in knowledge as a percentage of GDP, 2004



Source: OECD (2007), *Science, Technology and Industry (STI) Scoreboard 2007.*
Note: The OECD Scoreboard indicates that for all countries, investment in higher education refers to 2003. Investment in R&D and software refers to 2003 for some countries and 2004 for the rest. For Belgium, Australia and Austria the period of reference for the change in investment in knowledge to GDP ratio is 1998-2003.

R&D performance and funding

Gross expenditure on research and development (GERD) is a core statistic of the national innovation system. GERD as a percentage of GDP is perhaps the most common indicator for international ranking of technological capacity, and many countries set GERD/GDP targets. The USA last year announced a target of 3 per cent, while Finland has a target of 4 per cent. In 2002, the European Union set a target of 3 per cent for its members to achieve by 2010; few EU countries are likely to meet this target. Australia's ratio of GERD to GDP was 2.06 per cent in 2006-07.[15]

GERD can be examined from two different viewpoints. These are by:

- Source of funds - which shows the GERD estimates broken down by which sector has funded or paid for the R&D expenditure (Table 1)
- Performance - which shows the same GERD estimates broken down by the sector which actually performed or undertook the R&D (Table 2).

15 OECD, Main Science and Technology Indicators databases, 2009/2.

Table 1: GERD by source of funds, 1984–85 to 2006–07 ($ million real terms)[16]

	1984-85	1986-87	1988-89	1990-91	1992-93	1994-95	1996-97	1998-99	2000-01	2002-03	2004-05	2006-07	Annual Growth#
Business	1,614	2,558	3,228	3,455	4,365	5,101	5,915	5,526	5,928	7,795	8,879	11,746	9.4%
Australian Government	3,318	3,396	3,454	3,671	4,101	4,236	4,723	4,645	4,832	5,371	6,148	6,957	3.4%
State Government	628	656	765	942	884	1,000	938	997	997	962	918	1,069	2.4%
Other Australian	140	171	212	227	391	485	541	571	607	702	628	684	7.5%
Overseas	62	59	104	103	181	215	254	305	445	550	621	545	10.4%
Total GERD	**5,762**	**6,841**	**7,763**	**8,398**	**9,922**	**11,037**	**12,371**	**12,045**	**12,808**	**15,380**	**17,193**	**21,000**	**6.1%**

Source: ABS (2008), *Research and Experimental Development, All Sector Summary, Australia, 2006–07*, cat. no. 8112.0; special ABS data request and DIISR calculations. # Compound Average Annual Growth Rate (CAGR)
Note: Sum of components may differ slightly from total due to rounding.

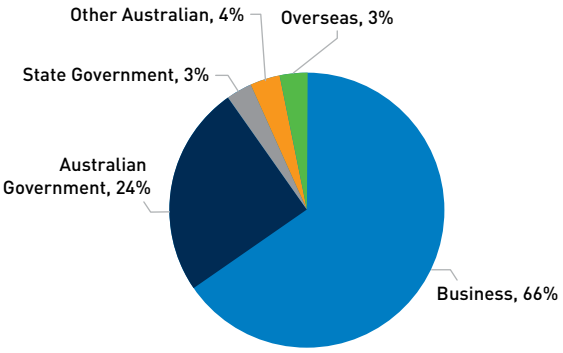
GERD by source of funds

Table 1 shows GERD financed by business, government, and other sources over the period 1984-85 to 2006-07. It shows that, at 6.1 per cent, the annual compound growth rate in the last twenty-two years in real terms has been considerable. Although all sectors increased their funding, the business sector led with annual growth of 9.4 per cent to be valued at $11.7 billion in 2006-07.

Chart 2 shows that, by funding, businesses contributed 66 per cent of the absolute GERD increase between 1984-85 and 2006-07. This considerable shift in the structure of R&D funding over more than two decades is a positive trend in the Australian innovation system as R&D funding has become an important contributor to business' competitive strategy.

Australian Government funding for R&D grew at a relatively slower annual rate (3.4 per cent), but still contributed 24 per cent of the absolute increase in GERD. In 2006-07, it accounted for $7 billion out of a total of $21 billion of GERD. This figure does not include the government support through the R&D Tax Concession, an Australian Government program that assists R&D undertaken by business, and which provided $815 million of assistance in 2006-07.[17]

Chart 2: Contribution to absolute increase in GERD by source of funds, 1984-85 to 2006-07



Percentage of the total GERD increase over 22 years

Source: ABS (2008), *Research and Experimental Development, All Sector Summary, Australia, 2006–07*, cat. no. 8112.0; special ABS data request and DIISR calculations

16 GERD Chain Volume measures are DIISR calculations using ABS BERD Implicit Price Deflator (IPD) time series. Chain Volume measure = Current Price/IPD. Base Year = 2006-07.

17 Department of Innovation, Industry, Science and Research (DIISR) (2009), *The Australian Government's 2009 10 Science and Innovation Budget tables*, Table 1, p. 2. The 2009–10 Science and Innovation Budget tables show the estimated cost of this program for 2006-07.

Table 2: GERD by sector of performance, 1984-85 to 2006-07 ($ million real terms)

	1984-85	1986-87	1988-89	1990-91	1992-93	1994-95	1996-97	1998-99	2000-01	2002-03	2004-05	2006-07	Annual Growth#
Business	1,731	2,594	3,257	3,377	4,380	5,186	5,959	5,530	6,126	8,080	9,207	12,036	9.2%
Australian Government	1,602	1,606	1,586	1,663	1,768	1,764	1,782	1,593	1,727	1,783	1,715	1,893	0.8%
State Government	684	731	866	1,078	1,023	1,157	1,122	1,166	1,169	1,107	1,065	1,061	2.0%
Higher Education	1,642	1,801	1,959	2,144	2,594	2,705	3,247	3,451	3,430	3,993	4,668	5,404	5.6%
Private non-profit	104	108	95	137	156	226	261	304	355	419	538	606	8.3%
Total GERD	**5,762**	**6,841**	**7,763**	**8,398**	**9,922**	**11,037**	**12,371**	**12,045**	**12,808**	**15,380**	**17,193**	**21,000**	**6.1%**

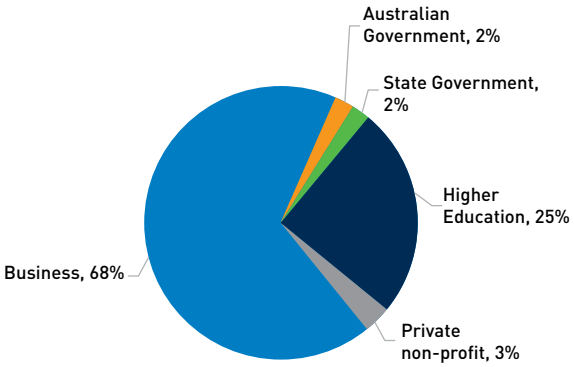
Source: ABS (2008), *Research and Experimental Development, All Sector Summary, Australia*, 2006–07 cat. no. 8112.0; special ABS data request and DIISR calculations # Compound Average Annual Growth Rate (CAGR)
Note: Sum of components may differ slightly from total due to rounding.

GERD by sector of performance

GERD performance data provides a sectoral breakdown of spending on R&D. In line with the funding trend, there has been an increase in real terms of GERD performed by the business sector.

Chart 3 shows that, by performance, businesses' contribution to the absolute increase in GERD was 68 per cent while higher education's contribution was 25 per cent. The private non-profit sector contributed with 3 per cent, while the Australian Government and state and territory governments both contributed 2 per cent of the GERD growth.

Chart 3: Contribution to absolute increase in GERD by sector of performance, 1984-85 to 2006-07



Percentage of the total GERD increase over 22 years

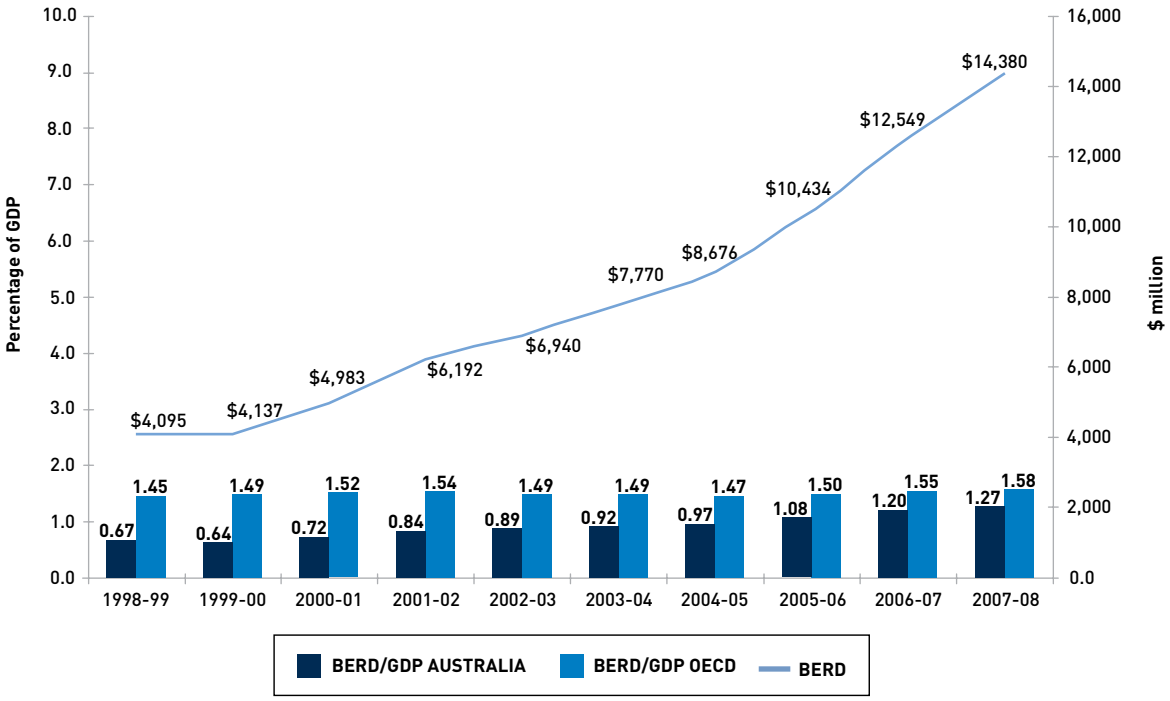
Source: ABS (2008), *Research and Experimental Development, All Sector Summary, Australia, 2006–07*, cat. no. 8112.0; Special ABS data request and DIISR calculations

Business R&D performance

In 2007-08, Australian businesses reported expenditure on R&D of $14.38 billion – an increase of 15 per cent from 2006-07 (Chart 4). Over the five years to 2007-08, BERD has increased at an average annual rate of 12 per cent.

Australia's BERD to GDP ratio of 1.27 per cent remains below the OECD average of 1.58 per cent in 2007-08. The gap is closing, however, with Australia's proportion improving to 80 per cent of the OECD average, up from 46 per cent in 1998-99 as Chart 4 illustrates. Australia continues to rank fourteenth on BERD to GDP ratio among the thirty OECD countries.

Chart 4: Business expenditure on research and development (BERD), 1998-99 to 2007-08



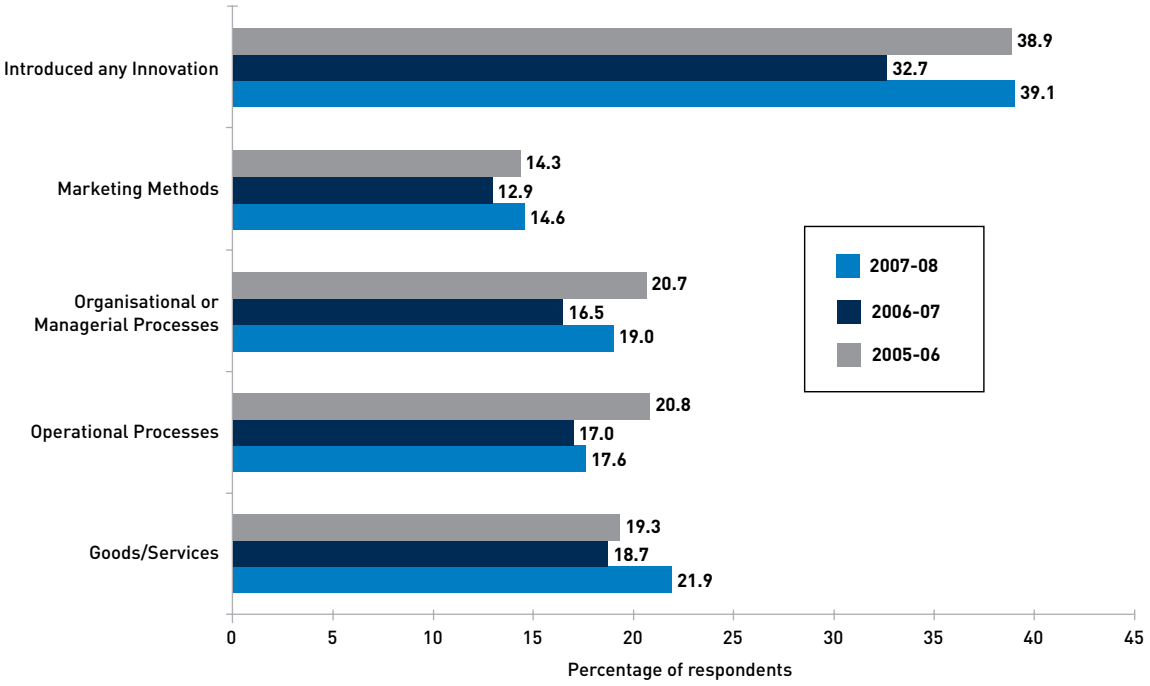
Source: ABS (2009), *Research and Experimental Development, Businesses, Australia, 2007-08, cat. no. 8104.0; and ABS (2008) Australian System of National Accounts, 2007-08*, cat. no. 5204.0.

Innovation in Australian businesses

Innovation is defined as implementation of a new or significantly improved product (goods or services), operational process, marketing method, or organisational method in business practices, workplace organisation or external relations.[18] 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. Over 2007-08, 39.1 per cent of Australian businesses reported the introduction or implementation of at least one type of innovation (see Chart 5 below).

There appears to be a shift from innovation in operational or organisational processes towards innovation in goods and services.[19] The most common type of innovation introduced in 2007-08 was new goods or services at 21.9 per cent of businesses surveyed, up 3.2 percentage points from 2006-07 (Chart 5). Businesses reporting new operational processes rose slightly from 17 per cent in 2006-07 to 17.6 per cent in 2007-08, while 19 per cent of businesses reported new organisational and managerial processes (up 2.5 percentage points), and 14.6 per cent reported new marketing methods (up 1.7 percentage points). The latest ABS innovation data for 2007-08 shows that 65.9 per cent of businesses with 200 or more employees introduced an innovation, compared to only 31.6 per cent of businesses with 0-4 employees.

Chart 5: Percentage of innovating Australian businesses by type of innovation, 2005-06 to 2007-08



Sources: ABS (2009), *Summary of IT Use and Innovation in Australian Business, 2007-08*, cat. no. 8166.0; ABS (2008), *Summary of IT Use and Innovation in Australian Business, 2006-07*, cat. no. 8166.0; and ABS (2007), *Summary of IT Use and Innovation in Australian Business, 2005-06*, cat. no. 8166.0.

18 OECD (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, third edition, OECD, Paris. This manual has been developed jointly by Eurostat and the OECD to aid in measuring the process of innovation.

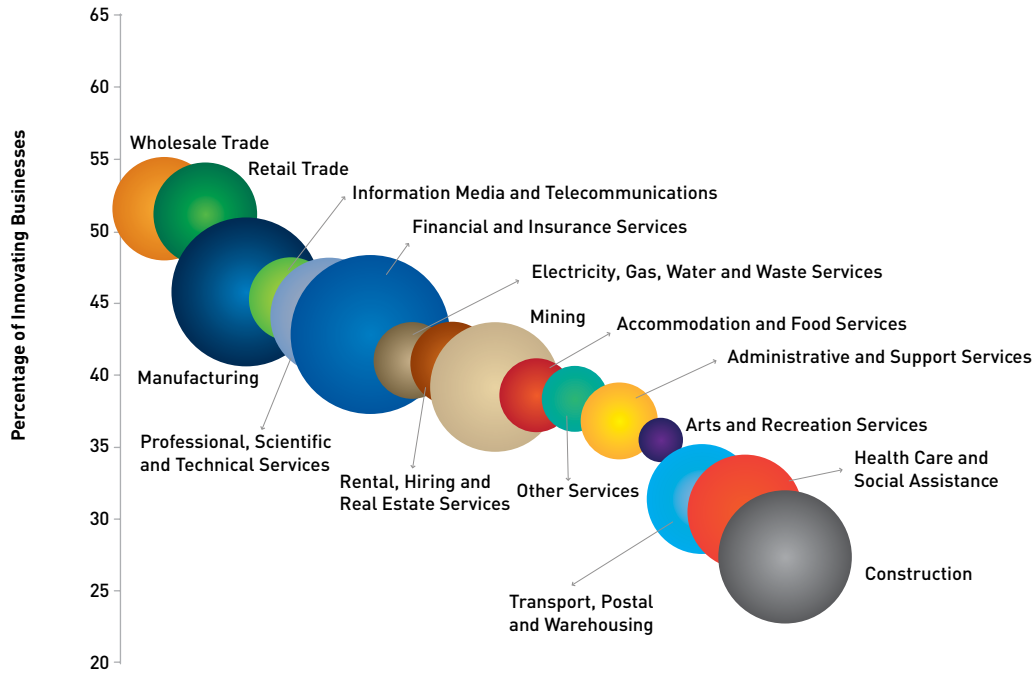
19 The ABS clarifies that for comparisons between 2006-07 and older editions scope changes associated with the adoption of an updated industry classification, the Australian and New Zealand Standard Industry Classification 2006 (ANZSIC06) for the 2006-07 Business Characteristics Survey (BCS) have affected comparability with data previously collected on the ANZSIC93 basis. The data presented here are not directly comparable to those released in earlier issues of the cat. no. 8166.0. or releases from previous stand-alone surveys of innovation in Australian business.

Sectoral innovation

The proportion of innovators in an industry rather than R&D intensity better captures the level of innovation across industry sectors. The proportion of innovators is useful because it allows comparisons between sectors to be less influenced by inherent differences. For example, the pharmaceuticals industry is inherently more R&D- intensive than retailing, but both may exhibit similar proportions of innovative businesses.

In Chart 6, the size of the bubbles represents how important the industry sector is to the Australian economy, measured as its proportion of gross value added (GVA). The vertical axis of the bubbles represents the proportion of innovating businesses in that industry sector, so large bubbles on the left side represent sectors that are both economically important and have a high percentage of innovating firms.

Chart 6: Percentage of innovating businesses by industry sector and percentage of gross value added (GVA), (bubble size = percentage of GVA), 2007-08



Sources: ABS (2009). *Summary of IT Use and Innovation in Australian Business, 2007-08*, cat. no. 8166.0; ABS (2008). *Australian System of National Accounts, 2007–08*, Table 5, cat. no. 5204.0; and DIISR calculations.

The median percentage of innovating Australian businesses surveyed by the ABS in 2007-08 is 40 per cent. Of those surveyed, the top five innovating industry sectors accounted for 29 per cent of GVA and employed 35 per cent of the total economy wide workforce.[20]

Notably, the manufacturing sector contributes 10.1 per cent to GVA and has 45 per cent of businesses innovating. Wholesale trade and retail trade ranked at the top of innovating sectors with 51.4 per cent and 50.9 per cent of innovating firms respectively. Each contributes about half as much to GVA as manufacturing.

20 ABS (2007) *Census Tables, Census of Population and Housing, Australia, 2006*, cat. no. 2068.0.

Challenges in collaboration and linkages

Collaboration and effective links between individuals, firms and industry and research institutions are vital to enable transformation of knowledge into economic value. Collaboration plays a key role in an organisation's capacity to absorb and access knowledge. Analysis of the 2003 Innovation in Australian Business data indicated that collaboration is associated with a 62 per cent higher probability of developing new-to–the-world innovations by large firms and 73 per cent for small firms compared with their non-collaborating counterparts.[21]

It is therefore troubling that collaboration and networking are consistent weaknesses in the Australian innovation system, particularly in comparison with the world's most innovative countries.[22] Australia lags significantly behind leading OECD countries in collaboration for innovation, particularly between large firms and higher education institutions.[23] The World Competitiveness Report 2009-10 classifies Australia as competitively disadvantaged on measures of networking and linkage such as cluster development and value chain breadth.[24]

National aggregate data on collaboration in innovation activities published by the ABS shows that 84 per cent of innovation-active businesses had no collaborative arrangements in 2006-07.[25] Disaggregated data by firm size, sector and type of collaborator allows a closer analysis. For example, 60 per cent of large, innovation-active mining firms undertook collaboration compared to only 13 per cent of innovation-active manufacturing SMEs.

Chart 7 shows considerable diversity in the type of organisation with which different industry sectors collaborated. For example, collaboration in the construction sector is highly dominated by clients, customers and buyers (88 per cent), while the electricity, gas, water and waste services sector collaborate actively with suppliers of equipment, materials, components, and software. Mining is the sector that collaborated most widely with universities and other higher education institutions, with almost one in five innovation-active mining firms undertaking collaboration with the higher education sector.

21 ABS (2005), *Innovation in Australian Business 2003*, cat. no 8158.0; and Department of Industry, Tourism and Resources (DITR) (2006), *Collaboration and other factors influencing innovation novelty in Australian business: An econometric analysis*, Australian Government, Canberra. This analysis does not imply a causal relationship.

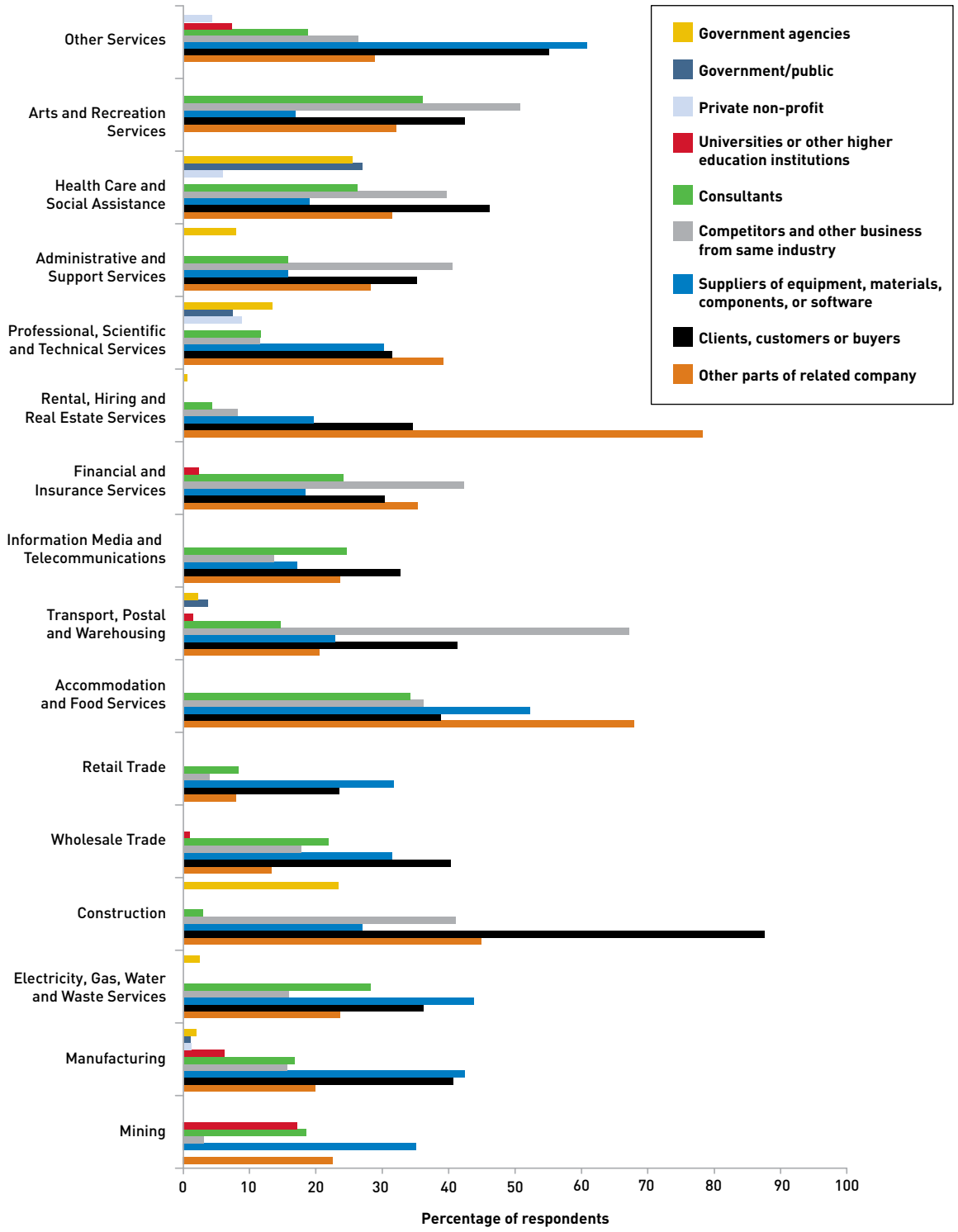
22 Cutler, T (2008), *Venturous Australia. Review of the National Innovation System*, Cutler & Company Pty Ltd, Melbourne; and Roos, G, Fernstrom, L and Gupta, O (2005), *National innovation systems: Finland, Sweden & Australia compared, learnings for Australia*, Australian Business Foundation, November 2005.

23 OECD, *Science, Technology and Industry Scoreboard 2009*. Arundel and O'Brien (2009) suggest that the collaboration data from Australia and European countries are not comparable as they refer to periods of different length. Arundel, A and O'Brien, K (2009), *Innovation Metrics for Australia*, a report commissioned by the Department of Innovation, Industry, Science and Research.

24 World Economic Forum (2009), *Global Competitiveness Report 2009–10*, Country profile: Australia, p.75.

25 Innovation-active: a business which, in the reference period, undertook any innovative activity irrespective of whether that innovation has been introduced or implemented, not yet completed or abandoned (ABS, cat. no. 8158.0).

Chart 7: Innovation-active business collaboration within Australia, by type of organisation collaborated with and by industry, 2006–07

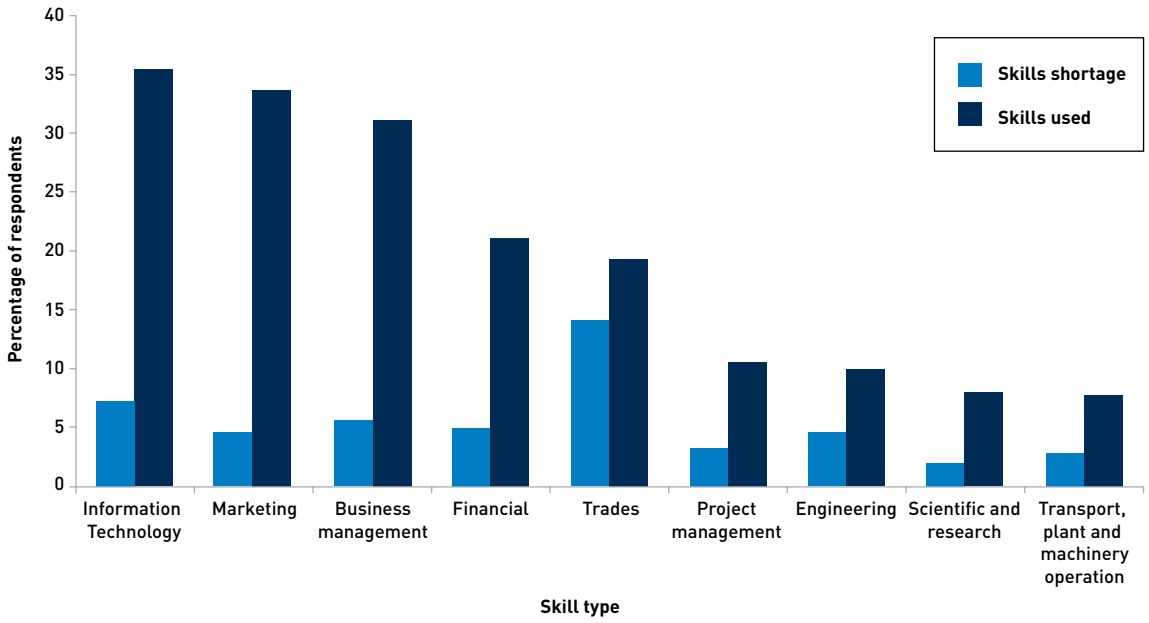


Source: ABS (2008), *Innovation in Australian Business, 2006-07*, cat. no. 8158.0.

Skill base in the innovation system

ABS data on skills used for innovation and the shortage of those skills is shown in Chart 8, ranked in decreasing order of relative importance. Information technology, marketing and business management rank highest, with engineering, science and research skills less prominent at the aggregate level. The largest shortage of skills required for innovation was in trades, a problem reported by 14 per cent of businesses.

Chart 8: Skills used and skills shortages for innovation-active businesses, by type of skills, 2006-07



Source: ABS (2008), *Innovation in Australian Business, 2006-07*, cat. no. 8158.0.

There are considerable differences in needs for specific skills when data is analysed at sector level. For example, 72 per cent of large manufacturing businesses indicated that engineering skills were used for innovation and 31 per cent reported there were shortages in these skills. Small manufacturing firms registered significantly lower percentages of skills used for innovation and of shortages in these skills. Similar trends appeared in mining, electricity, gas, water and waste services, and information technology skills.

This seems to suggest that large firms in most industry sectors undertake innovations that have a higher requirement for specialised skills. A possible exception is the professional, scientific and technical services sector in which SMEs showed significant shortages of skills in information technology and project management.

The recent *Management Matters in Australia* study commissioned by the Government to explore the role of management in innovation and productivity confirmed some of the trends identified in the innovation survey, such as differences in management skills and practices between large and small firms.[26] The report also provides some useful international comparisons with mixed results for Australian firms. While Australian management ranked sixth overall among sixteen countries covered by the study, the levels of tertiary qualifications within surveyed Australian firms (both management and non-management) were among the lowest.

One implication of the study is that a country's overall management performance is determined mainly by its tail of poor performers rather than the performance of its leading firms. It is instructive to note, for example, that the top 27 per cent of Indian and Chinese manufacturers are already better managed than the bottom half of Australian manufacturers.

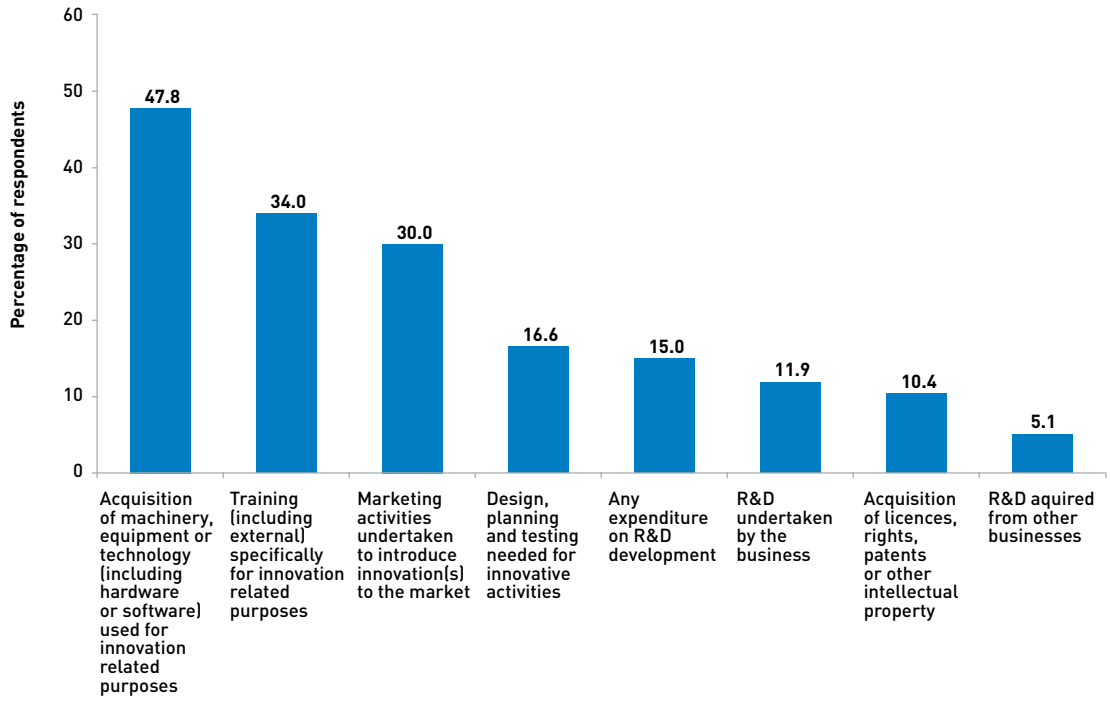
26 Green, R (2009), *Management Matters in Australia. Just how productive are we?* A report commissioned by the Department of Innovation, Industry, Science and Research.

Knowledge diffusion and adoption

Diffusion and adoption of innovations that do not require R&D are important.[27] Innovation is widespread – it is not just concentrated among a small number of firms that undertake R&D in high-technology sectors. Aggregate innovation expenditures in low-technology sectors are similar to those in high-technology sectors. The difference is that low-technology sectors spend a greater proportion of their innovation budget on technology acquisition, while high-technology sectors spend more on R&D.[28]

Similarly, in 2006–07, acquisition of machinery, equipment or technology was the most frequent type of expenditure for innovation purposes by innovation-active Australian firms (Chart 9). This was followed by expenditure on training and marketing activities. Other disembodied knowledge adoption strategies such as acquisition of patents, licences and other forms of intellectual property are less common for the overall economy, but important for particular industry sectors such as manufacturing, and information media and telecommunications. Higher proportions of businesses reported R&D expenditure in these two sectors; this suggests that R&D complements other strategies for increasing the capacity of these firms to innovate.

Chart 9: Expenditure for innovation purposes, Australian businesses, 2006-07



Source: ABS (2008), *Innovation in Australian Business, 2006-07*, cat. no. 8158.0

27 Evangelista, R, Perani, G, Rapiti, F and Archibigi, D (1997), 'Nature and impact of innovation on manufacturing industry: some evidence from the Italian innovation survey', *Research Policy*, vol. 26, pp.521–536; Smith, K (2002). 'What is the knowledge economy? Knowledge intensity and distributed knowledge bases', INTECH, Discussion Paper Series 2002–6, United Nations University, Maastricht; and Smith, K and West, J (2005), 'Australia's innovation challenges: building an effective national innovation system', *The Melbourne Review* vol. 1, pp.15–22.

28 Arundel, A and O'Brien, K (2009), *Innovation Metrics for Australia*, a report commissioned by the Department of Innovation, Industry, Science and Research.

Changes in support for areas of research in the Australian innovation system

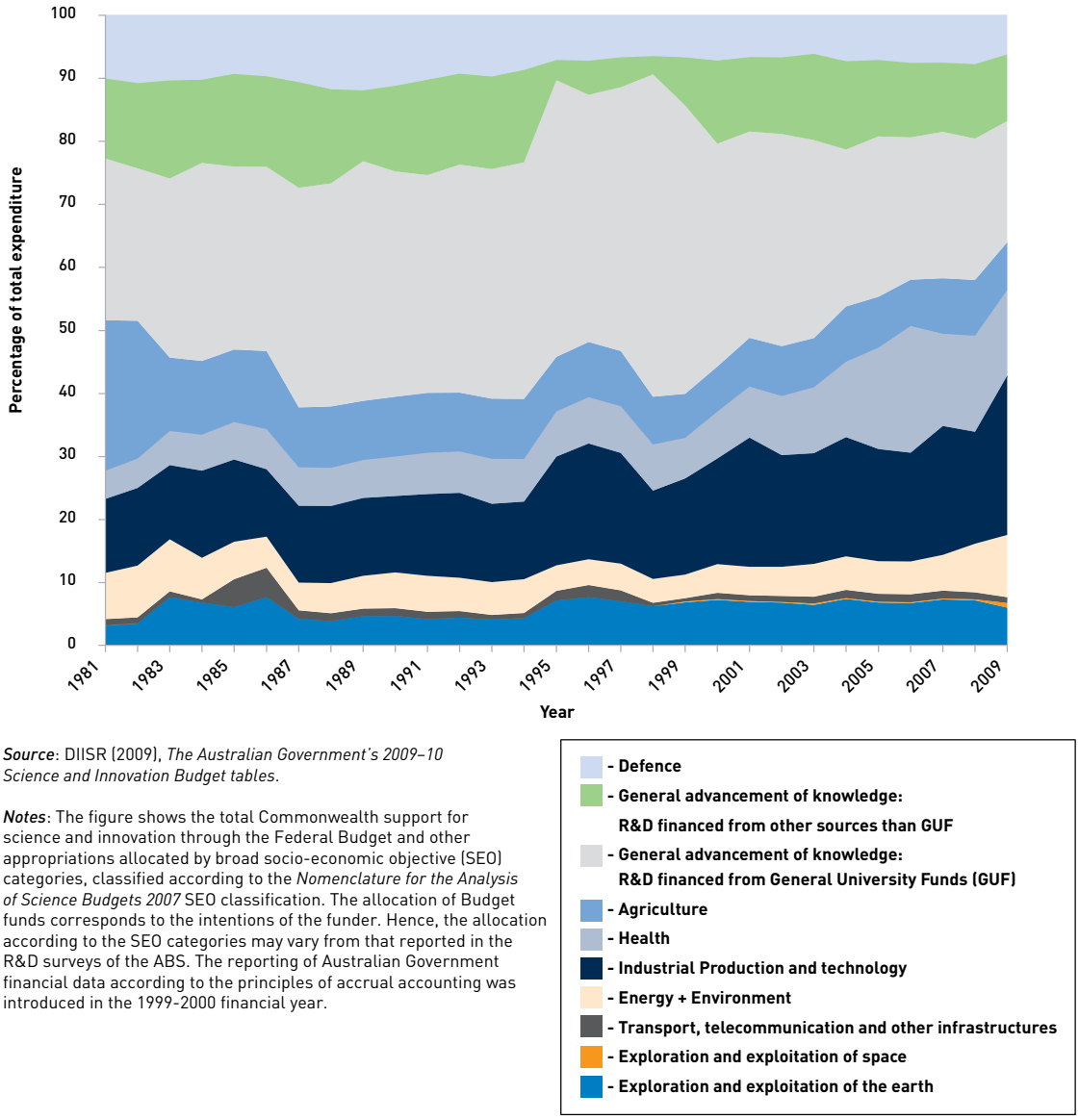
Chart 10 tracks the shares of Australian Government support for science and innovation by socio-economic objectives in the last ten years. The chart shows a significant decline in relative terms in the areas of general advancement of knowledge through both general university and non-university funding. On the other hand, there have been relative increases in socio-economic objectives related to industrial production and technology, health, energy and the environment.

Across portfolios, eco-innovation has become a major priority in the Government's innovation agenda as the 2009-10 budget data shows.

Low carbon and renewable energy programs shared 32 per cent ($1,053 million) of the major R&D granting programs and other support for science and innovation through the Budget which totalled $3,275 million.[29] This represents a change of 290 per cent with respect to the previous year, when 13 per cent ($270 million) of the innovation programs were allocated to climate change and related areas.

The Clean Energy Initiative, the Green Car Innovation Fund, the Global Carbon Capture and Storage Institute, the Low Emissions Technology Demonstration Fund and the National Clean Coal Initiative together accounted for 76 per cent of the funding for programs and other support for science and innovation.

Chart 10: Australian Government support for science and innovation by socio-economic objectives, 1981-82 to 2009-10



Source: DIISR (2009), *The Australian Government's 2009–10 Science and Innovation Budget tables*.

Notes: The figure shows the total Commonwealth support for science and innovation through the Federal Budget and other appropriations allocated by broad socio-economic objective (SEO) categories, classified according to the *Nomenclature for the Analysis of Science Budgets 2007* SEO classification. The allocation of Budget funds corresponds to the intentions of the funder. Hence, the allocation according to the SEO categories may vary from that reported in the R&D surveys of the ABS. The reporting of Australian Government financial data according to the principles of accrual accounting was introduced in the 1999-2000 financial year.

29 Same as reference 1

Small sized firms in the Australian economy

Small sized firms[30] feature prominently in the Australian economy. Not only do they account for the majority of businesses in Australia, they make a large contribution to GVA and are an important source of employment in the Australian economy. In 2006, small sized firms represented 99.4 per cent of all enterprises in Australia, accounted for 47.6 per cent of Australia's GVA, provided jobs and income for 53.1 per cent of employed persons (Table 3). The dominance of small sized firms in the Australian economy raises important considerations for innovation policy and research. An obvious implication is expected low levels of investment in innovation and R&D because small businesses have greater difficulties in appropriating the results of innovation and R&D so they have fewer incentives to invest in these activities.

ABS firm-size data on businesses which introduced or implemented new or significantly improved products show that large firms outperform small firms in terms of product innovation in most industries. The ratio of innovating businesses in Manufacturing between large firms (more than 200 employees) and small firms is 1.7 to 1 and in information media and telecommunications it is 4 to 1.[31] A higher proportion of small firms reported barriers to innovation than large firms.[32]

As shown in Table 3, compared to other OECD countries, Australia has an above average share of small sized firms in GVA and employment. For instance, Australia ranked seventh out of eighteen OECD countries in 2007 for share of small firms in GVA and ranked fifth out of eighteen OECD countries for small firms as a share of total employment.

Table 3: Share of small sized firms in gross value added (GVA) and total employment, Australia and selected OECD countries, 2007

Country	Small firms as a share of GVA (%)	Rank	Country	Small firms as a share of total Employment (%)	Rank
Poland	77.9	1	Greece	76.0	1
Greece	57.6	2	Italy	68.5	2
Italy	55.7	3	Spain	63.2	3
Austria	51.9	4	Hungary	54.7	4
Spain	50.6	5	**Australia**	**53.1**	**5**
Luxembourg	50.3	6	Norway	51.5	6
Australia	**47.6**	**7**	Belgium	50.8	7
Norway	45.5	8	Netherlands	50.5	8
Denmark	44.5	9	Poland	50.2	9
Netherlands	42.0	10	Austria	48.3	10
France	39.7	11	Czech	47.7	11
Belgium	39.4	12	Ireland	46.3	12
Sweden	38.5	13	France	45.5	13
Finland	35.1	14	Sweden	45.4	14
Czech	34.8	15	Luxembourg	43.1	15
Germany	34.3	16	Finland	41.4	16
Hungary	33.7	17	Germany	36.8	17
Ireland	29.1	18	Denmark	34.5	18
OECD Average	**44.9**		**OECD Average**	**50.4**	

Source: OECD (2008), Structural and Demographic Business Statistics database.
Note: Data presented for available OECD countries. Data refers to 2007 reference year period or latest available year not exceeding 2006. Small firms defined as businesses employing 0-49 persons in Australia and New Zealand or, 1-49 persons, in countries of the European Union.

30 Firm sizes are based on the *standardised* firm size classification developed by the OECD. According to this classification system, micro sized firms employ 0-9 persons and small sized firms employ 10-49 persons. For the purposes of this report, small refers to the sum of micro and small business, therefore all firms with less than 50 employees.

31 ABS (2008), *Innovation in Australian Business, 2006-07*, cat. no. 8158.0. Please note that the ABS definition of small business used in this survey is 5-19 employees, which is different to the OECD definition.

32 ABS (2009), *Selected Characteristics of Australian Business, 2007-08*, cat. no. 8167.0.

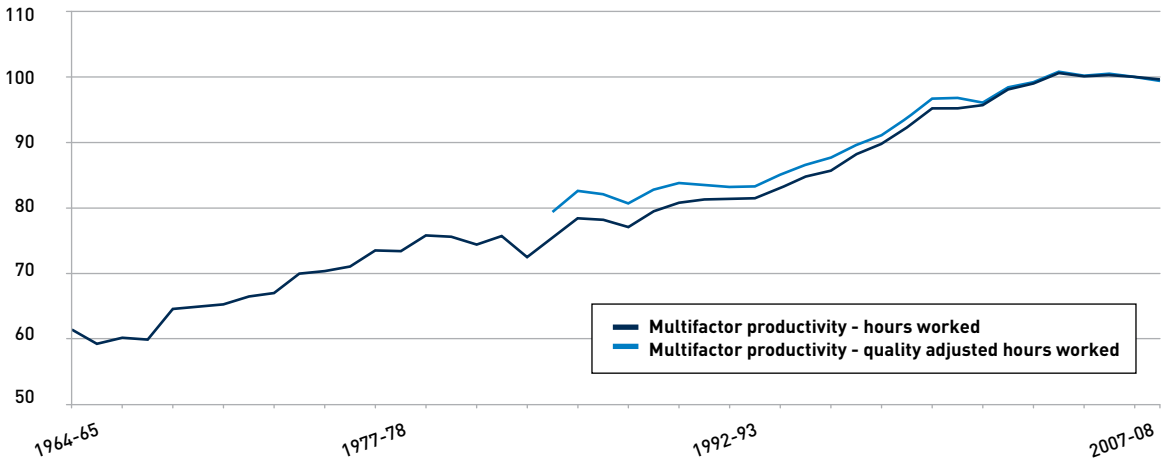
Innovation and rising levels of productivity

According to Nobel Laureate economist Paul Krugman, "productivity isn't everything, but in the long run it is almost everything". Rising productivity is critical to long-term increases in living standards.[33] Its importance is underlined by the Productivity Commission's finding that 65 per cent of economic growth per capita in Australia over the last four decades can be attributed to increases in multi-factor productivity (MFP).[34]

Australia's MFP growth can be seen in Chart 11 below. Australia recorded significant productivity growth in the 1990s but since then it has stalled and declined slightly. Australia's MFP growth over the long term is slightly below the median of nineteen OECD countries, ranking Australia twelfth overall.[35] In the longer term it will be necessary to address this decline in MFP to support rising incomes.

The Australian Government has made restoring productivity growth in Australia a priority. It recognises that productivity must be lifted if we want higher wages for workers, better returns for investors, and lower prices for consumers; there is no other way to achieve all three. Over the past two years and more, the Government has systematically pursued an agenda to improve Australia's productivity performance. The four items on that agenda are the Education Revolution, to increase workforce skills; investment in nation-building infrastructure, to remove bottlenecks and capacity constraints; deregulation, to minimise the cost and complexity of doing business; and the innovation objectives outlined in *Powering Ideas*, which are all about harnessing Australia's science and research capabilities to drive the transformation of existing industries and the growth of new ones.

Chart 11: Australia's multi-factor productivity, 1964-65 to 2007-08, 2006-07=100



Source: ABS (2008), *Australian System of National Accounts, 2007-08,* cat. no. 5204.0, p.10.

Economic research[36] has established that innovation is one of the key drivers of long run increases in productivity. Innovation enables inputs such as capital and labour to be combined in new ways to produce higher-value goods and services, to increase efficiency, or to address social and environmental problems. The most obvious and recent example of the impacts of innovation can be seen in the development of ICT. Innovations in computing led to increased production relying less on human and physical resources in industries ranging from cars to banking. The impact of innovation can also be seen in developments in solar and wind power which promise to reduce Australia's reliance on fossil fuels. Showcase 1 illustrates how an innovation generated in an Australian publicly funded research agency (PFRA) has had a massive impact on the ICT business sector, with almost certain high productivity gains.

33 Productivity is commonly defined as the ratio of the quantity of outputs to the quantity of inputs and is a key indicator of economic performance. Increases in productivity can result from minimising the use of inputs for a given output or maximising output for a given input. Productivity measures (e.g. labour productivity and multi-factor productivity, MFP) are of policy interest because they are linked to standards of living, and tell us something about the long-run sustainability of economic growth.

34 Productivity Commission (2007), *Public Support for Science and Innovation*, Productivity Commission, Canberra, p.110.

35 Productivity Commission (2009), *Submission to the House of Representatives Inquiry on Raising the Level of Productivity Growth in the Australian Economy*, September 2009, p11.

36 Pilat, D. (1998), OECD *Observer*, vol.a, 1998.

Dr John O'Sullivan
Image provided by CSIRO

SHOWCASE 1: WLAN – CSIRO'S TECHNOLOGY INCORPORATED IN HUNDREDS OF MILLIONS OF ELECTRONIC DEVICES

The worldwide adoption of CSIRO's Wireless Local Area Networking (WLAN) invention has increased the productivity of users of notebook computers and led to the development of new applications and devices. These include cameras, hand-held games consoles that can connect multiple users, and smart phones which, when indoors, connect at high data rates to the internet without clogging telecommunications networks.

The invention came out of pioneering research work in radioastronomy by Dr. John O'Sullivan and his team at CSIRO. That work involved complex mathematics known as 'Fast Fourier Transforms' as well as detailed knowledge about radio waves and their behaviour in different environments. Indoor environments are particularly difficult for the rapid exchange of large amounts of data using radio waves. CSIRO solved these problems in a unique way in the early 1990s, a time when many of the major communications companies around the world were trying, but with less success, to solve the same problem.

CSIRO's patented technology is essential to the implementation of common industry standards for high speed wireless communications indoors. Following settlements of patent litigation in the US, CSIRO's patent is licensed to 15 companies, including Hewlett-Packard, Intel, Dell, Toshiba, ASUS, Microsoft and Nintendo, under confidential terms. The revenue arising from these settlements to October 2009 was approximately $205 million.

Forecasters predict that there are likely to be more than a billion devices sold worldwide over the next several years using the technology invented by CSIRO scientists.

In recognition of this important innovation, Dr. O'Sullivan was awarded the prestigious 2009 Prime Minister's Prize for Science.

Economic theory has long identified a strong link between innovation activity and productivity growth, a link which can be practically demonstrated through econometric techniques. A highly influential study which examined this issue was conducted by OECD economists Dominique Guellec and Bruno van Pottelsberghe in 2001. Using data from sixteen OECD countries over nearly two decades, the analysis looked at the impacts of private and public R&D on productivity.

Their findings indicate a strong relationship between R&D and productivity, with a 1 per cent increase in business R&D correlating with 0.13 per cent increase in MFP over the long term. Similarly, a 1 per cent increase in public R&D leads to a 0.17 per cent increase in productivity over the long term. While this figure does not seem large in the context of MFP as a whole, the size of the effect is perhaps seen more clearly when comparing it to the average increase in MFP of 0.8 per cent over the period 1997-98 to 2007-08.[37]

37 Gullec, D and Van Pottelsberghe, V (2001), *From R&D to Productivity Growth: Do the Institutional Settings and Source of Funds Matter?* OECD, Paris.

A more recent multi-country study made findings that related specifically to Australia. It found that both public and private R&D had significant effects on productivity in Australia. A 1 per cent increase in business R&D would lead to a 0.11 per cent increase in productivity while a 1 per cent increase in public R&D would lead to a 0.28 per cent increase in productivity. The study concluded that knowledge, along with human capital, was a key driver of productivity growth in Australia and other countries.[38]

A recent UK assessment looked at innovation more broadly, examining the impact of investments in R&D as well as other areas of innovation such as training, design and software development. It found that innovation was responsible for two-thirds of the UK's private sector labour productivity growth over 2000-07, resulting in an average annual increase in productivity of 1.8 per cent.[39]

The role of government

Government helps to create favourable conditions for innovation by managing the economy responsibly, regulating effectively and facilitating the free flow of investment, people and ideas. As the OECD has noted, however, while these framework conditions provide a sound basis for innovation, they are not sufficient by themselves. Government also plays an important role by supporting the development of the research and innovation infrastructure which comprises the knowledge, skills and institutions necessary to identify and exploit new products, processes and organisational changes.[40]

Government supports research and innovation infrastructure through a number of mechanisms, such as:

- providing support in the form of grants and tax incentives to overcome market failures that discourage private investment in innovation, not least the reluctance of financiers to provide capital for innovative but untried products
- providing support in some circumstances for industries to adjust to structural changes in the economy and facilitate shifting resources for higher productivity and growth in future years
- providing support for the identification and implementation of innovative changes in businesses to build their internal capacity and capitalise on their growth potential
- funding vital research – especially basic research – that would not or could not be done by the private sector
- improving interactions between the different actors in the innovation system such as firms, universities and PFROs
- seeking new and better inputs from the private sector and developing new and better ways to deliver its own services.

The Australian Government is spending $8.6 billion in science and innovation in 2009-10, compared to $6.9 billion in 2008-09, an increase of 25 per cent. A quarter of the Government's innovation investment goes towards programs that encourage business investment in innovation, including R&D tax incentives. The remainder is shared between the higher education sector, research agencies and multi-sector initiatives such as the Cooperative Research Centres Program.

38 OECD (2006), *Sources of Knowledge and Productivity: How Robust is the Relationship*, STI Working Paper 2006/6.

39 National Endowment for Science, Technology and the Arts (NESTA) (2009), *The Innovation Index: Measuring the UK's investment in innovation and its effects*, NESTA, United Kingdom.

40 OECD (2001), *The New Economy: Beyond the Hype, Final Report on the OECD Growth Project, OECD, France*; and OECD (2005), *Micro-Policies for Growth and Productivity*, OECD, France.

CHAPTER TWO

Research capacity and skill base

Innovation arises from a complex interplay between many elements of an innovation system that is fundamentally underpinned by its research capacity and skill base. Research creates new ideas which fuel innovation. Skilled workers drive innovation, turning ideas into new products, services and processes for the benefit of the economy and society.

Research undertaken in Australia's public and private sectors enables firms, government agencies and the community to create, absorb and deploy new ideas. Research determines our potential for innovation and our capacity to access and benefit from advancing knowledge as it shapes economic competitiveness and social change. Our highly-skilled workforce contributes to productivity and economic growth through its role in the creation, adoption and diffusion of innovations, and by sustaining society's store of knowledge and transmitting it to future generations.

In *Powering Ideas*, the Australian Government set priorities and targets for the nation's research capacity and skill base.

Priority 1: Public research funding supports high-quality research that addresses national challenges and opens up new opportunities.

Target: The Australian Government's ambition is to increase the number of research groups performing at world class levels, as measured by international performance benchmarks.

Priority 2: Australia has a strong base of skilled researchers to support the national research effort in both the public and private sectors.

Target: The Australian Government's objective is to significantly increase the number of students completing higher degrees by research over the next decade.

This chapter provides highlights of Australia's research capacity and skill base and its performance against other OECD countries. It summarises key achievements addressing the priorities and targets by Commonwealth and state and territory governments. It also presents case studies illustrating the important role that higher education institutions and PFROs play in the Australian innovation system by maintaining and improving national research capacity and the skills base.

Highlights of baseline performance

Research capacity

A country's research capacity is often measured by its investment in R&D and its output of scientific publications. Table 4 summarises Australia's performance in research capacity compared with other OECD countries across a set of indicators, including its rankings against all other OECD countries and its distance from the top five OECD countries. It shows that Australia is among the top one-third of the thirty OECD countries for R&D expenditure in the public sector and number of scientific publications. Australia falls to the middle one-third, however, on indicators of gross domestic investment in R&D (including both public and private investment) and the quality of scientific publications. Australia is between 13.7 per cent and 72.2 per cent below the averages of the top five OECD countries across the indicators.

Table 4: Australia's performance in research capacity against other OECD countries

Indicators	Latest Figure	Reference Year	OECD Ranking	Gap from the Top Five OECD Performers	Data Source
GERD as a % of GDP	2.06%	2006	12th	37.9%	(1)
GERD per capita (current PPP$) [a]	$734	2006	13th	38.0%	(1)
Government-financed GERD as a % of GDP	0.77%	2006	6th	13.7%	(1)
GBAORD as a % of GDP	0.57%	2009	22nd [b]	45.0%	(1)
HERD as a % of GDP	0.52%	2006	9th	24.6%	(1)
GOVERD as a % of GDP	0.28%	2006	9th	29.7%	(1)
Share of world publications	3.18%	2008	9th	72.2%	(2)
Publications per thousand researchers	413.8	2008	9th	31.2%	(2)
Citations per publication	5.31	2004-08	16th	25.5%	(2)
Relative impacts of publications	1.13	2004-08	16th	25.7%	(2)
Number of fields with higher than world average citation rate by field*	19	2004-08	- (c)	-	(2)

Sources: (1) OECD, Main Science and Technology Indicators database, 2009/2. (2) Thomson ISI, National Science Indicators database, 2008.
Notes: Indicators with * and in the coloured rows of the table are the primary indicators applied to measure and monitor progress against the Australian Government's innovation targets. (a) PPP$: Purchasing Power Parity. (b) Turkey is not included. (c) -: Not available.

The most commonly used measures of research capacity are gross expenditure on research and development (GERD) relative to GDP and population. Australia's GERD amounted to 2.06 per cent of GDP or $734 per capita (in current PPP$) in 2006, resulting in a ranking of twelfth and thirteenth among thirty OECD countries respectively.

Governments are a major source of funds for R&D in OECD countries. Government-financed GERD indicates the amount of a country's gross domestic R&D expenditure directly funded by its governments at all levels - national, provincial and municipal. Australia's government-financed GERD stood at 0.77 per cent of GDP in 2006, ranked sixth among OECD countries on this indicator. Government budget appropriations or outlays on research and development (GBAORD) provide a different measure of government support for R&D by counting only national government spending. Australia's GBAORD accounted for 0.57 per cent of GDP in 2009, ranked twenty-second in the OECD.

R&D expenditure by universities and PFROs shows the magnitude of a country's investment in public research. Higher education expenditure on research and development (HERD) provides a measure of R&D performed in the higher education sector.[41] Australia's HERD accounted for 0.52 per cent of GDP ($5.4 billion) in 2006, ranked Australia ninth among OECD countries. Government expenditure on research and development (GOVERD) indicates the size of R&D performed in the government sector.[42] Australia's GOVERD was $2.9 billion, representing 0.28 per cent of GDP in 2006. For R&D expenditure by government research agencies as a share of GDP, Australia ranked equal ninth with Japan among OECD countries.

R&D expenditure is a measure of research input. Scientific publications, on the other hand, can be used as a measure of a country's research output. The total number of Australian research publications reached a record 36,111 in 2008. This constituted 3.18 per cent of world total, ranking Australia ninth among OECD countries. When measured by the number of publications per thousand researchers (413.8), Australia again stood at ninth place on the OECD league table.

41 The OECD definition of the higher education sector encompasses universities and other institutions of post-secondary education regardless of their source of finance or legal status. The scope of the ABS R&D survey in the higher education sector is based on the OECD definition, but excludes colleges of Technical and Further Education.

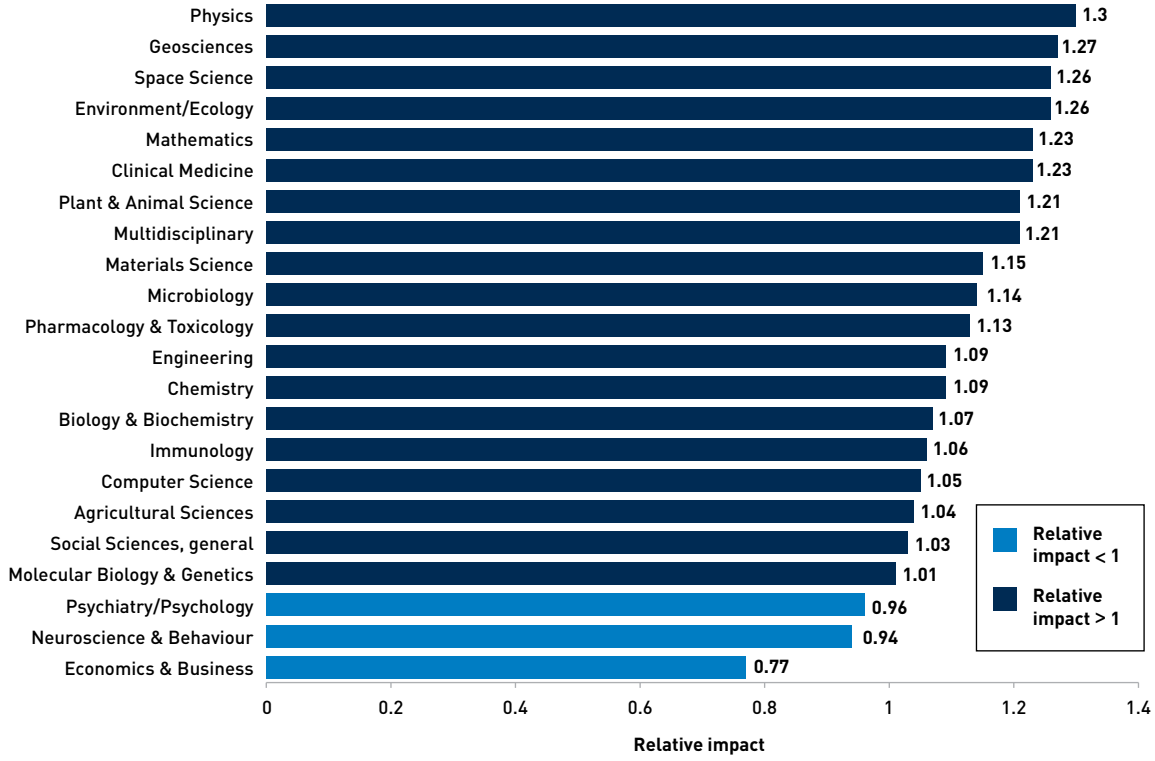
42 The general government sector comprises all government units of the Commonwealth Government, state and territory governments and each local government authority, and all resident non-market, non-profit institutes (NPIs) that are controlled and mainly financed by those governments. The scope of the ABS R&D survey in the government sector is based on the OECD definitions, including organisations such as CSIRO, ANSTO, and Geoscience Australia.

The number of citations per publication indicates the impact of a country's research output. With 5.31 citations per research publication over the five-year period 2004-08, Australia ranked sixteenth among the OECD countries. The relative impact of Australia's publications (the national citation average divided by the world average), was 1.13 over the period 2004-08, ranking Australia sixteenth among OECD countries.

The number of research fields where Australia has a higher than world average citation rate by field, is another proxy indicator of the quality of a country's research output. It also highlights a country's relative strengths in international research.

This indicator is applied as an interim measure of progress against the Australian Government's target to increase the number of research groups performing at world-class levels. It is expected that data to more directly measure such progress will become available when Excellence in Research for Australia (ERA) is implemented in 2010-11. As shown in Chart 12, out of twenty-two research fields, Australia had nineteen with a relative impact higher than 1 over 2004-08.

Chart 12: Relative impacts of Australian scientific publications – by field, 2004-08



Source: Thomson ISI, National Science Indicators database, 2008.
Note: The relative impact of Australian publications is calculated as the number of citations per Australian publication divided by the number of citations per world publication by field over the period 2004-08.

Skill base

A country's skill base is commonly measured by the number and type of highly qualified people active in the labour force. Table 5 presents a summary of Australia's skill base compared with other OECD countries. It shows Australia is among the top one-third of OECD countries for gross expenditure on tertiary education, proportion of population with a tertiary qualification, new PhDs, and professionals and technicians in total employment.

Australia's performance is moderate, however, when compared to other OECD countries on indicators of public investment in tertiary education, new graduates with science and engineering qualifications, R&D personnel in total employment, and researchers in total labour force. Australia's gap from the top five OECD countries range between 8.6 per cent for professionals and technicians and 43.2 per cent for public expenditure on education.

Table 5: Australia's performance in skill base against other OECD countries

Indicators	Latest Figure	Reference Year	OECD Ranking	Gap from the Top Five OECD Performers	Data Source
Tertiary education expenditure as a % of GDP	1.63%	2006	6th [a]	29.4%	(1)
Public expenditure on tertiary education as a % of GDP	1.13%	2006	15th [a]	43.2%	(1)
Proportion of population aged 25-64 with tertiary education	33.7%	2007	8th	18.5%	(1)
Proportion of population aged 25-34 with tertiary education	40.7%	2007	9th	20.5%	(1)
Number of students completing higher degree by research in Australia*	**7,478**	**2008**	**- [b]**	**-**	**(2)**
Science & Engineering university graduates as a % of total university graduates	20.4%	2007	20th [c]	35.1%	(3)
PhD graduation rate	1.9%	2006	7th [c]	39.2%	(1)
Share of professionals and technicians in total employment	35.8%	2008	7th	8.6%	(4)
R&D personnel as a % of total employment	1.23%	2006	15th [d]	33.5%	(5)
Researchers as a % of total labour force	0.81%	2006	11th	34.5%	(5)

Sources: (1) OECD, *Education at a Glance 2009: OECD indicators*. (2) DEEWR, *Award course completions 2008: selected higher education statistics*. (3) OECD, Online Education database. (4) OECD, *Science, Technology and Industry Scoreboard 2009*. (5) OECD, Main Science and Technology Indicators database, 2009/2.
Notes: Indicators with * and in the coloured rows of the table are the primary indicators applied to measure and monitor progress against the Australian Government's innovation targets. (a) Excluding Greece and Luxembourg. (b) -: Not available. (c) Excluding Luxembourg. (d) Excluding the USA.

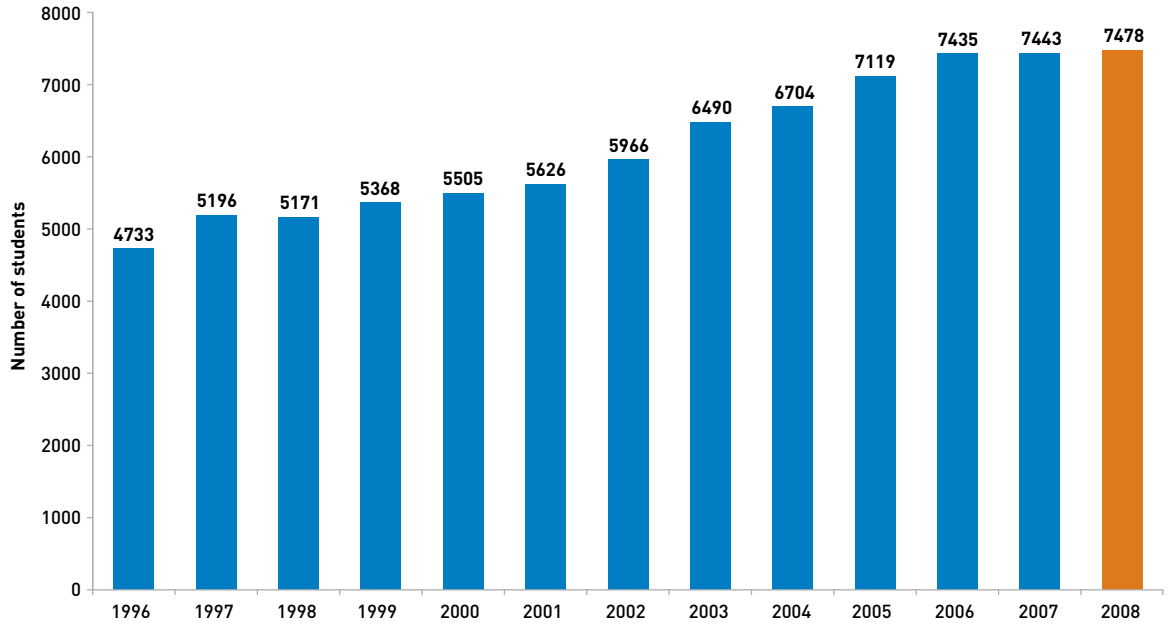
Total tertiary education expenditure as a share of GDP measures the proportion of a nation's wealth that is invested in tertiary education institutions. In Australia, tertiary education expenditure accounted for 1.63 per cent of GDP in 2006, sixth among OECD countries. Public expenditure on tertiary education stood at 1.13 per cent of GDP, ranked fifteenth.

While expenditure indicates the resources directed to education and skill formation, it is also important to measure the skill base formed through education. Educational attainment at the tertiary level is a commonly used proxy for the stock of human capital, that is, the skills available in the population and the labour force. Around 33.7 per cent of the population aged 25-64 in Australia had a tertiary education qualification in 2007. The proportion was 40.7 per cent for the population aged 25-34. Compared to other OECD countries, Australia ranked eighth for the group aged 25-64 and ninth for 25-34 year olds.

The number of new university graduates indicates a country's potential for assimilating, developing and diffusing advanced knowledge and supplying the labour market with highly skilled workers. The number of students who complete higher degrees by research provides a pointer to the future supply of research workers. In *Powering Ideas*, the Government set a target to significantly increase the number of students completing higher degrees by research over the next decade.[43] Chart 13 shows that since 1996 the number of students completing higher degrees by research in Australia increased by 58 per cent, to 7,478 students in 2008.

43 Higher degrees by research include: Higher Doctorate, Doctorate by Research, Doctorate by Coursework and Master's by Research.

Chart 13: Number of students completing higher degrees by research, 1996 to 2008



Source: DEEWR, *Award course completions 2008: selected higher education statistics.*

Science and engineering skills are particularly important to R&D. In 2007, new university graduates with a science and engineering degree accounted for approximately 20.4 per cent of new university graduates in Australia. This is relatively low by international standards, ranked twentieth out of thirty OECD countries. At the typical age of graduation, around 1.9 per cent of the population in Australia completed a doctoral degree in 2006, ranked seventh among OECD countries.

The stock of workers employed in professional and technical occupations is a measure of the highly qualified section of the labour force, which is of critical importance to innovation performance. In 2008, workers in professional and technical occupations comprised 35.8 per cent of total employment in Australia, ranked seventh in the OECD.

R&D personnel and researchers expressed as a share of total employment or labour force enables comparison of human resources devoted to R&D activities. In 2006, 1.23 per cent of total employment was related to R&D activities, while researchers accounted for 0.81 per cent of total labour force in Australia. This placed Australia fifteenth and eleventh respectively in the OECD.

Supporting high-quality public research

Achievements and actions by the Australian Government

Enhancing the quality of higher education research

Mission-based compacts

In 2009, the Australian Government announced a ten-year higher education reform strategy in two key reports: *Transforming Australia's Higher Education System* and *Powering Ideas: An Innovation Agenda for the 21st Century*. This strategy includes the development of a new partnership with universities through the introduction of mission-based compacts. The Government has been working with universities to develop compacts defining each university's particular mission and describing how it will fulfil that mission and meet the Government's policy goals.

Mission-based compacts aim to promote excellence and build capacity and international competitiveness in Australia's university sector. They will assist individual universities to capitalise on their strengths and to articulate the unique role they play in the higher education system, the innovation system, their local region and community, and internationally.

During 2009, the Government released a discussion paper on mission-based compacts, organised a series of roundtable consultations with the higher education sector to discuss development of the compacts framework, and met each university individually to negotiate interim agreements for the following year. The interim agreements were published in March 2010. The Government will refine the compacts framework in preparation for negotiating compacts for 2011 towards the end of 2010.

Sustainable Research Excellence in Universities

Also announced in the 2009-10 Budget, Sustainable Research Excellence (SRE) in Universities supports world-class innovative research by addressing the identified shortfall in funding to meet indirect costs associated with the conduct of research funded by competitive project grants. SRE also improves the overall financial management, performance and reporting frameworks of universities. SRE will provide $510 million in additional funding over the initial four-year period and approximately $300 million (indexed) annually from 2013-14. Funding under this initiative commenced in 2010. When combined with existing Research Infrastructure Block Grant funding, this additional funding will ensure that universities are better placed to undertake quality research on a sustainable basis.

The Department of Innovation, Industry, Science and Research has released a number of documents to detail the activities universities are required to undertake in 2010 to be eligible for the Threshold 1 and Threshold 2 funding elements of SRE. The most significant activity in 2010 is the trialling of Transparent Costing, in which universities quantify the indirect costs associated with competitive grants.

Better Indexation of HESA Funding for Research

The Australian Government is committing $51.6 million across 2011-12 and 2012-13 to improve the indexation of funding for research. The current indexation methodology for Research Block Grants funded under the *Higher Education Support Act 2003* (HESA) will be replaced with a more appropriate methodology from 2012.

The revision of indexation will ensure that indexation arrangements better reflect actual increases in the costs associated with research and research training and in living expenses supported by Research Block Grants to universities. The measure will address a decline in the real value of these grants in recent years.

Excellence in Research for Australia

Excellence in Research for Australia will evaluate the quality of research undertaken in Australian higher education institutions, using a combination of indicators and peer review, and compare Australia's research effort against international benchmarks. The objectives of ERA are to:

- establish an evaluation framework that gives assurance of the excellence of research conducted in Australia's institutions
- provide a national stocktake of discipline-level areas of research strength and areas where there is opportunity for development
- identify excellence across the full spectrum of research performance
- identify emerging research areas and opportunities for further development
- allow for comparisons of Australia's research nationally and internationally for all discipline areas.

In 2009, the ARC undertook a trial evaluation of two discipline clusters – the Physical, Chemical and Earth Sciences cluster and the Humanities and Creative Arts cluster. The outcomes of the trials will inform the full ERA process, which will involve an evaluation of all eight discipline clusters. Institutions will commence submitting material for ERA in mid-2010.

Increasing investment in research infrastructure

Super Science Initiative

The Super Science Initiative was announced in the 2009-10 Budget, providing a $1.1 billion boost for critical areas of scientific endeavour. It includes a $901 million investment in new infrastructure to support research in three areas in which Australia excels – space science and astronomy, marine and climate science, and the platforms that will underpin future industries, including nanotechnology and biotechnology.

Examples of research infrastructure projects supported by the initiative include additional funding for the Anglo-Australian Observatory's four-metre Anglo-Australian Telescope (AAT), and nuclear science facilities for the Australian Nuclear Science and Technology Organisation (ANSTO). According to an independent study, the AAT is the most productive and highest-impact four-metre telescope in the world, ranked fifth overall against telescopes of any size, on the ground or in space. The establishment of a Centre for Accelerator Science and the Neutron Beam Instrument Program will ensure that ANSTO can continue to provide the Australian research community with first-class facilities to support research in areas of national importance. These two projects are scheduled to be completed by mid-2013.

These investments in research infrastructure are highly collaborative in nature, building on the principles established by the National Collaborative Research Infrastructure Strategy. The funded projects were identified as priorities in the 2008 *Strategic Roadmap for Australian Research Infrastructure*. Once established, the research infrastructure will be accessible by researchers from PFROs and private industry across Australia.

Education Investment Fund

The Education Investment Fund (EIF) was established by the Australian Government in 2008. Its role is to build a modern, productive, internationally competitive Australian economy by supporting world-leading, strategically focused capital infrastructure investments that will transform Australian tertiary education and research.

In December 2008, $118.5 million was allocated for two research infrastructure projects under EIF Round 1. In the 2009-10 Budget, a further $321.7 million was provided under EIF Round 2 for eight strategic and innovative research infrastructure projects. These investments will provide facilities to support research collaboration in priority areas including marine science, climate change, molecular science and materials R&D.

Supporting collaborative research in priority areas

Australian Space Science Program

The Australian Government's Australian Space Research Program (ASRP) and Space Policy Unit were announced in the 2009-10 Budget as part of the Australian Space Science Program.

The ASRP will provide $40 million over four years through a competitive, merit-based grants program to eligible consortiums. The objective of the program is to develop Australia's niche space capabilities by supporting space-related research, innovation and skills in areas of national significance or excellence. The first grant recipients were announced in February 2010. The second grant round opened the following month, with successful applicants to be announced in July 2010.

The Space Policy Unit was established on 1 July 2009 within DIISR. It provides advice to the Government on civil space matters. Allocated $8.6 million over four years, the unit has established contact mechanisms to fulfil its mandate as the central point of contact and coordination for all of Australia's national and international civil space activities.

National Climate Change Adaptation Research Facility

In 2007, the Australian Government established the National Climate Change Adaptation Research Facility. The facility is hosted by Griffith University in partnership with the Department of Climate Change to focus on climate change adaptation issues. The facility is backed by a consortium with seven other universities and the Queensland Government. It is leading the development of a number of National Adaptation Research Plans (NARPs), which identify critical gaps in information needed by decision-makers, industry and the community; set research priorities based on these gaps; and identify capacity that can be harnessed to conduct priority research.

NARPs and grants funding were announced in 2009 to fund research into the human health impacts of climate change through the National Health and Medical Research Council's research grants program, and research into emergency management and climate change. Other NARPs currently being developed cover terrestrial biodiversity, marine biodiversity and resources, settlements and infrastructure, primary industries, freshwater biodiversity and social, economic and institutional dimensions.

Commonwealth Environment Research Facilities

The Commonwealth Environment Research Facilities Program (CERF) provides $20 million a year to support research that improves Australia's capacity to understand and respond to priority environment concerns. It promotes research in areas of special strength or need, with a strong focus on public good outcomes.

Supporting high-quality research

Australian Research Council

The Australian Research Council (ARC) provides advice to the Australian Government on research matters and manages the National Competitive Grants Program (NCGP), a significant component of Australia's investment in R&D. The NCGP supports the highest-quality fundamental and applied research and research training across all disciplines. NCGP funding is allocated competitively on the basis of research excellence determined by peer review. Two examples of the ARC's research funding programs under the NCGP are *Discovery Projects* and *Centres of Excellence*.

Discovery Projects is the ARC's largest scheme that funds research projects by individual researchers or research teams. Selection rounds are conducted annually. In the round for funding commencing in 2010, 925 successful proposals have been awarded a total of more than $325 million over five years. The success rate was 22.7 per cent. Of the approved proposals, 90.2 per cent have indicated that their research falls within one of the four National Research Priority areas. Also awarded were a range of fellowships supporting researchers in different stages of their careers, including 112 Australian Postdoctoral Fellowships, 64 Australian Research Fellowships and Queen Elizabeth II Fellowships and 27 Australian Professorial Fellowships.

A bibliometric study by the Australian National University indicates that 10 per cent of Australian-authored publications in the period 2001-05 that were indexed by Thomson Reuters' Web of Science resulted from research funded under the *Discovery Projects* scheme.[44] The relative citation impact of these publications (1.17) exceeds both the Australian average (1.11) and world average (1.00). Among the research fields where the relative citation impact for research supported under the Discovery Projects scheme is highest are Agricultural, Veterinary and Environmental Sciences (1.63), Earth Sciences (1.45) and Physical Sciences (1.39).

ARC Centres of Excellence are prestigious hubs of expertise through which high-quality researchers maintain and develop Australia's international standing in research areas of national priority. They involve significant collaboration which allows complementary resources of universities, PFRAs, other research bodies, governments and businesses to be concentrated to support research. A selection round for funding commencing in 2011 is currently under way. The successful centres will be selected through a competitive two-stage process which includes an expression of interest and a full application phase. The successful centres will be awarded $1 million to $4 million per year for up to seven years.

National Health and Medical Research Council

The National Health and Medical Research Council (NHMRC) is Australia's peak body for supporting health and medical research, for developing health advice for the Australian community, health professionals and governments, and for providing advice on ethical behaviour in health care and in the conduct of health and medical research. In 2008-09, NHMRC disbursed $699.3 million in research funding, of which $442.3 million was allocated to research support programs. Three examples of NHMRC research support funding programs are:

Project Grants is NHMRC's largest funding scheme supporting individual researchers and research teams to conduct the highest quality research across all fields of research relevant to health. In 2009, 683 Project Grants worth more than $383 million were awarded to universities and research institutions to enable Australia's best health and medical researchers to continue their work.

Program Grants provide funding support to leading health and medical research teams in Australia. In 2009, fifteen research teams were awarded $108 million to contribute new knowledge in important areas of health and medical research and develop training and career development opportunities.

The Centres of Research Excellence Scheme seeks applications from teams of researchers to pursue innovative, high-quality collaborative research in priority areas. Funding is awarded for a period of five years. The centres are expected to generate new knowledge that leads to improved health outcomes for the community, advance the training of researchers, facilitate collaborative use of specialised facilities and expertise across multiple disciplines, and ensure effective transfer of research outcomes into policy and practice.

NHMRC regularly commissions an independent analysis of the publication impact of NHMRC funding. The most recent study found that:

- 36.6 per cent of NHMRC publications had one or more international authors and 52.4 per cent had authors from more than one institution within Australia, indicating high levels of collaboration in NHMRC-funded research
- 47.9 per cent of NHMRC's international publication collaborations are with the US, 16.5 per cent with the UK and 10.3 per cent with Germany.

44 ARC (2009), *ARC-supported research: the impact of journal publication output 2001–05*, report prepared by the Research Evaluation and Policy Project, Australian National University.

Achievements and actions by state and territory governments

Western Australia

Western Australian Major Research Facility Program

The Western Australian Major Research Facility Program creates high-impact scientific research facilities to address problems and opportunities of great importance to Western Australia. The objective of the program is to establish large, world-class research facilities, building on local science and innovation excellence.

Established in 2004, the program provides support for facilities for a four to five-year term. Four major research facilities have been established to date, covering a diversity of fields, all of which are multidisciplinary research collaborations with industry participation. The facilities are the Western Australian Energy Research Alliance; the Western Australian Marine Science Institution; the Centre for Food and Genomic Medicine; and the International Centre for Radio Astronomy Research.

South Australia

The Plant Accelerator

South Australia's Waite Precinct is home to a new world-leading plant growth and analysis facility, the Plant Accelerator. The $26 million high-technology glasshouse, with over 1 kilometre of conveyor systems and state-of-the-art imaging, robotic and computing equipment, will enable continual measurement of the physical attributes of up to 160,000 plants a year. This will accelerate research into improving drought and salt tolerance in wheat and barley as well as accommodating research into other economically important crops such as grapevines.

The Plant Accelerator further cements the Waite Precinct as one of Australia's leading research, education and commercialisation clusters, with the largest concentration of expertise in the southern hemisphere for plant biotechnology, cereal breeding, sustainable agriculture, wine and horticulture and land management. The Plant Accelerator will serve as the national headquarters of the Australian Plant Phenomics Facility, which has nodes in Adelaide and Canberra.

Establishing a strong base of skilled researchers

Achievements and actions by the Australian Government

Increasing funding for research training

International Postgraduate Research Scholarships

The International Postgraduate Research Scholarships (IPRS) program is part of the Research Block Grant funding provided to Australian universities by the Commonwealth. It aims to attract top-quality international postgraduate students to areas of research strength in Australian universities. A total of 330 IPRS places are awarded each year at a cost of around $20 million. The Government has undertaken an evaluation of the IPRS program which identifies trends in IPRS recipients' participation in the Australian research workforce, and their potential involvement with Australian research following completion of their scholarship. The evaluation found that the IPRS program is meeting its objectives, is well-aligned with the Australian Postgraduate Awards and continues to make a significant contribution to current government policy in the area of higher education research.

Australian Postgraduate Awards

The Australian Postgraduate Awards (APAs) are available to students of exceptional research potential undertaking a doctorate or masters by research degree at an eligible Australian higher education institution. APAs are provided to assist with students' general living costs for a period of up to three years. The Government is progressively doubling the number of APAs on offer and in 2010 it increased the stipend by 10 per cent.

Increasing funding for researchers in different stages of their careers

Australian Laureate Fellowships

The Australian Laureate Fellowships scheme was announced in September 2008. The scheme aims to attract world-class researchers and research leaders to key positions, and create new rewards and incentives for researchers to apply their talents in Australia. For funding commencing in 2010, the scheme provides a $102,025 annual salary top-up for five years, funding for project costs, and salaries and stipends for postdoctoral and postgraduate researchers to work with the Laureate Fellows.

In June 2009, the first selection round awarded fifteen fellowships to distinguished Australian and international researchers. Of these, two fellowships were awarded to Australians intending to return to Australia, one to a foreign national and twelve to resident Australians.

Future Fellowships

The $844 million Future Fellowships scheme aims to promote research in areas of critical national importance by giving outstanding researchers incentives to conduct their research in Australia. Over a five-year period (2009-13), the Future Fellowships scheme will offer four-year fellowships of up to $140,592 per year (for funding commencing in 2010) to 1,000 outstanding Australian and international researchers in the middle of their career. In addition, the host organisations will receive funding of up to $50,000 per year to support related infrastructure, equipment, travel and relocation costs.

The first 200 Future Fellows were announced in September 2009. Of these, forty-one will come to Australia to pursue their research – nineteen Australians have been attracted home and twenty-two international researchers will bring their talents to Australia.

Super Science Fellowships

The ARC will administer 100 new Super Science Fellowships for early-career researchers, as part of the Super Science Initiative. The objectives of the Super Science Fellowships are to attract and retain outstanding early-career researchers in three key areas of existing research strength: space and astronomy, marine and climate science, and the enabling technologies that will support future industries. The fellowships are expected to strengthen collaboration in the targeted disciplines across research institutions and organisations, while strengthening Australia's research capacity by supporting innovative, internationally competitive research.

Of the 100 fellowships on offer, fifty may be awarded in Round 1 for funding commencing in 2010, and a further fifty may be awarded in Round 2 for funding commencing in 2011. The institutions awarded Super Science Fellows in Round 1 are expected to be announced by June 2010.

Enhancing workforce innovation skills

Workforce Innovation Program

The Workforce Innovation Program (WIP) is an element of the broader Australian Government approach to workforce development and improving workforce productivity. WIP provides funding for innovative, one-off projects that address workforce and skills development needs.

It is designed to support industry stakeholders to increase productivity by piloting workforce development solutions that help them better use emerging technologies and processes.

Projects under WIP are usually undertaken over twelve to thirty-six months. The projects undertaken in 2009-10 have targeted: piloting innovative solutions to industry skills needs; strengthening industry leadership in reform of the training system; supporting the Government's response to climate change, particularly with strategies supporting the development of green skills; and supporting a more innovative culture.

Increasing awareness and understanding of science and innovation

Questacon – The National Science and Technology Centre

Questacon aims to increase awareness and understanding of science and innovation through inspirational learning experiences, including interactive science exhibitions, travelling programs, online content and science theatre. Over the reporting period, its major achievements include:

- Questacon Smart Moves Invention Convention, an annual week-long program for innovative secondary school students to develop entrepreneurial skills to further develop their ideas
- Following a review of Questacon and the release of the report *Stepping up to Meet National Needs* in September 2008, the Australian Government provided an extra $11.3 million for Questacon in the 2009-10 Budget, including dedicated funding for outreach activities.
- In 2008-09, Questacon collaborated with Scitech to develop educational resources for the Square Kilometre Array (SKA), including the touring I-Dome (an interactive SKA exhibit) and an interactive SKA show.
- In 2009-10, Questacon will develop its interactive digital outreach capabilities to complement its outreach programs to regional, rural and remote communities via live, broadband communications technology.

Inspiring Australia: A National Strategy for Engagement with the Sciences

On 8 February 2010, the Australian Government released *Inspiring Australia: A National Strategy for Engagement with the Sciences*. It provides a national approach for community engagement with the sciences. The strategy was developed in consultation with stakeholders by the Questacon Division of the Department of Innovation, Industry, Science and Research.

Key findings of the report include:

- Communicating science effectively is important to achieving an innovative Australia and national leadership and coherent action are required.
- Australia is a high-performing country across the sciences, and this should be acknowledged and attract appropriate reward and recognition.
- Australia has a small population and needs to ensure that it capitalises on all potential talent. Therefore, it is important to develop the interest of Australians irrespective of geography, ethnicity, age or social condition.
- A capable science workforce is a prerequisite for the Australian Government's innovation agenda. Students therefore need positive experiences to maintain their interest in science and mathematics to ensure an adequate supply of professionals with appropriate skills.
- To achieve the goal of a scientifically engaged Australia, we need the combination of a national framework and local action; a strong web presence; and improved information flow and organisational networking. A supportive research and evaluation program is also needed to monitor progress and inform investment decisions.

Achievements and actions by state and territory governments

New South Wales

Life Science Research Awards

This program has succeeded in bringing leading life sciences researchers to New South Wales, and enabling them to further their research in NSW institutions. Recipients of the awards receive up to $220,000 from the NSW Government, with matching funding from the host institution. The Life Science Research Awards, offered from 2006 through to 2011, are an expansion of the BioFirst awards which commenced in 2002. These awards led to funding for thirteen scientists, the expansion or establishment of nine laboratories, and the direct employment of thirty-nine staff. Research groups funded under the Life Science Research Awards have subsequently published sixty-two papers and leveraged nearly $7 million in grants from agencies including the NHMRC and the ARC. Funded research has translated into real economic, health, environmental and social benefits for the state.

Queensland

Smart Futures Fund

The Smart Futures Fund, with an expansion on the existing fellowship programs, was launched in 2008 under the Queensland Government's *Smart State Strategy: Queensland's Smart Future 2008-12*. It includes:

- Premier's Fellowship – a $1.25 million initiative over five years to build leadership capacity within Queensland's research community and to position Queensland at the forefront of cutting-edge research and innovation.
- Fellowships – $150,000 (Level 2) or $300,000 (Level 1) over three years for talented early career and mid-career researchers working in leading Queensland-based research team.
- Commercialisation Fellowships for Researchers-in-Residence – up to $100,000 per year for six to twenty-four months to encourage better collaboration between industry and researchers, increase the uptake of new ideas within industry, and drive the development of knowledge-intensive industries.
- Commercialisation Fellowships for Entrepreneurs-in-Residence – up to $100,000 a year for three to eighteen months to increase commercialisation skills and business management experience within research institutions to translate research, technologies and ideas into new products, processes and services
- Commercialisation Fellowships for Innovation Investment Exchange – up to $45,000 for twelve to thirty weeks for Queensland venture capital firms to engage in exchange programs with overseas venture capital firms.
- Queensland International Fellowships – up to $44,000 for three to nine months for Queensland-based researchers to travel overseas and work with an international research partner.

In 2008-09, one Premier's Fellowship, 12 Fellowships, and two Commercialisation Fellowships were awarded. Total funding committed during this period was $4 million. Funding agreements have been executed with all recipients and research projects will be completed over the next three to five years.

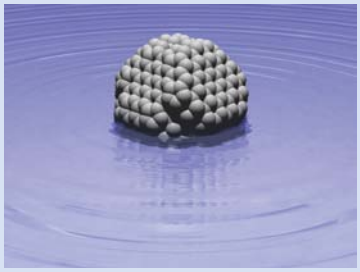
CASE STUDIES: UNIVERSITIES

Dr Amanda Barnard
Image by Bearcage Pty Ltd

Dr Amanda Barnard, Physical Scientist of the Year

Dr Barnard received the 2009 Malcolm McIntosh Prize for Physical Scientist of the Year in Australia for her early career achievements. Her PhD thesis created an analytical theory and computer model that predicted and explained the various forms of nano-carbon at different sizes. It was the first study of its kind to be recognised by both theorists and experimentalists and resulted in seventeen journal publications and a book chapter.

Dr Barnard returned to Australia in 2008 with the help of a University of Melbourne Future Generation Fellowship. She is a Queen Elizabeth II Australian Research Council Fellow and heads CSIRO's Virtual Nanoscience Laboratory. She leads the world in her field of nanomorphology – predicting the shape, structure and stability of nanoparticles. Her current research hopes to predict which nanoparticles will work most efficiently and which could be dangerous. She uses supercomputers to make the particles in the virtual world and tests how they interact in various environments before they are made in the real world.



Computer-generated model of a diamond nanoparticle in water.
Image by Amanda Barnard, CSIRO

Dr Barnard's current projects illustrate the breadth of application of her modelling. For instance, she has helped create a way of delivering chemotherapy drugs using diamonds. Nanodiamonds are non-toxic but have reactive surfaces that can carry drugs. They also cluster together, so the release of the drug is slow and sustained. Using her theoretical knowledge of diamonds and the national supercomputer she found that an electrical charge would gently break the particles apart, so changes in pH could be used to influence delivery.

Dr Jerome Maller
Image by SDP Photography

Dr Jerome Maller

Many people develop major depression after a traumatic brain injury, and most do not respond to the usual anti-depressant treatments. Dr Jerome Maller believes he can predict who is most likely to develop depression. He is using an advanced magnetic resonance imaging technique that shows subtle changes in the white matter (connecting fibres) in the brain. This technique, known as diffusion tensor imaging, could shed light on who will develop depression and thus enable individuals at greater risk to receive early intervention treatment.

Jerome is a neuroscientist in the Brain Stimulation and Neuroimaging laboratory at the Monash Alfred Psychiatry Research Centre. In May 2008, he was awarded a Victorian Neurotrauma Initiative (VNI) Early Career Research Fellowship for three years. "The VNI support has allowed me to test my hypothesis by recruiting and brain scanning many people with and without a traumatic brain injury, and with and without major depression," says Jerome. "This has fast-tracked my research and opened the way for me to make significant advances in our understanding of traumatic brain injury and its relationship to major depression."

Controlling skin infections and scabies in Aboriginal communities

In 2005, the Menzies School of Health Research at Charles Darwin University initiated a project to help reduce the substantial burden of scabies and skin sores in remote Aboriginal communities. The project, which was led by Associate Professors Ross Andrews and Shelley Walton, involved a combination of clinical, healthy skin community treatment programs and biomolecular studies. This articulation between laboratory and public health has been extremely productive and allowed translation of research findings into improved clinical practice.

Significant benefits to Australia of this program include:

- a reduction in skin sore prevalence from 46.1 per cent to 27.6 per cent in a number of communities over the three-year period
- identification of a previously unrecognised burden of scabies and skin sores within the first few months of life
- vocational education training and formal qualifications for eleven Healthy Skin Workers
- the development of a diagnostic test for scabies
- a better understanding of the types of bacteria that cause skin infections and how bacteria and scabies mites develop resistance
- improved treatment strategies to reduce the impact of skin disease and associated chronic diseases, such as rheumatic fever and renal disease.

Charles Darwin University worked in partnership with the CRC for Aboriginal Health, the Queensland Government, the Australasian College of Dermatologists, the University of Melbourne and the Queensland Institute of Medical Research.

CASE STUDIES: PUBLICLY FUNDED RESEARCH ORGANISATIONS

National ICT Australia

National ICT Australia (NICTA) was established to address a long-term, structural under-investment in strategic information and communications technology (ICT) research. The Australian Government has committed $564.5 million to NICTA over the period 2002-15. The funding is supplemented by cash and in-kind contributions from member and partner organisations expected to exceed $190 million over the five years 2006-11.

NICTA's research addresses national issues such as security, transport, the environment, broadband, water management and health, including medical implants such as the bionic eye. Since its inception in 2002, NICTA has developed technologies enabling the establishment of four spin-out and two spin-in ventures. Over seventy new jobs have been generated by the spin-outs to date. In 2009, NICTA's major achievements were:

- Signing an agreement with Singapore's A*STAR Institute for Infocomm Research (I^2R) to develop and demonstrate fast, low-cost temporary mobile wireless communications networks. The system will allow people to connect using their mobile phones without the need for expensive infrastructure.
- Completing the world's first formal machine-checked proof of a general-purpose operating system kernel to prove mathematically that software governing critical safety and security systems in aircraft and motor vehicles is free of a large class of errors.
- Securing, through the spin-out company OK Labs, US$7.6 million in venture funding from Chrysalis Ventures, Neo Technology Ventures, and Citrix Systems. OK Labs' embedded hypervisor, OKL4, is now deployed in 250 million mobile phone handsets and other mobile or embedded devices worldwide.

NICTA has five research laboratories and undertakes a range of commercialisation activities to transfer its research outputs to the broader economy. In September 2009, NICTA had 255 research and research support staff (full-time equivalent) and supported 283 PhD students. NICTA is expected to increase its current level of research and research training activities with increasing levels of funding from sources other than the Australian Government, including commercial revenue.

GA and FESA jointly awarded the Asia-Pacific Spatial Excellence Award in the spatially enabling government category.

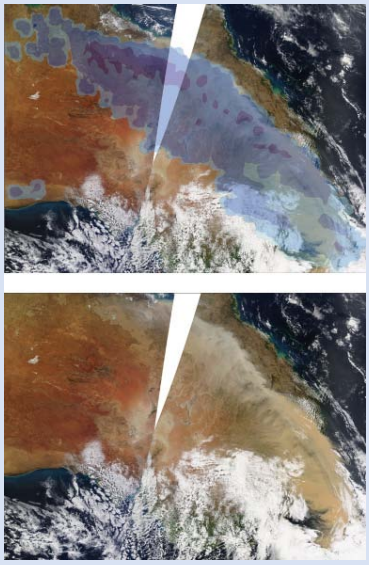
GA and FESA jointly awarded the EMA Safer Communities Award in the pre-disaster, cross-jurisdictional category 2007. L-R: John Butcher and Gordon Hall (FESA), Ole Nielsen (GA), Attorney-General, the Hon Robert McClelland MP, John Schneider, David Burbidge, Jane Sexton and Trevor Dhu (all GA). *Images provided by Geoscience Australia*

Tsunami Planning and Preparation

Modelling of natural hazards and quantifying the associated risk to urban communities is a complex and challenging task. A collaborative research partnership over 2005-09 between Geoscience Australia (GA) and the Fire and Emergency Services Authority of Western Australia (FESA) has developed one of the most rigorously tested and validated tools for analysing tsunami impact in international use. The outputs have been used by emergency managers to inform mitigation, planning and response decisions.

Development of tsunami hazard and risk modelling capabilities is relatively recent. Little comparable research exists internationally, so the program and outputs developed in Australia by GA and FESA stand at the forefront of innovation. The National Exposure Information System, developed by GA to define the built environment, has been used to support the risk analyses. Coupling this exposure data with a range of unique engineering impact models, the analysis has provided a level of detail not previously available in Australia for problems of this kind.

The quality of the science is demonstrated through two key outputs: the first offshore probabilistic tsunami hazard assessment in Australia and worldwide; and the first detailed tsunami impact assessments in Australia. The innovative nature of this work has been recognised both internationally and nationally and the onshore hazard modelling component was showcased on the ABC *Inventors* television program in 2009.



The performance of the ACCESS model can be tested by its ability to "forecast" known past events. The blue shading in the top image shows a dust plume forecast for eastern Australia, based on ACCESS model predictions made several hours ahead, for 23 September 2009. The forecast plume closely matches the actual dust plume as seen on a MODIS[45] satellite picture (bottom image). *Satellite images courtesy of NASA/GSFC, MODIS Rapid Response*

Australian Community Climate Earth System Simulator

The Australian Community Climate and Earth-System Simulator (ACCESS) is a fully-coupled numerical modelling system for simulating and predicting the behaviour of the atmosphere and the oceans and their interactions with each other and the surface of the land. ACCESS simulates the full earth system by using five modules that represent atmospheric chemistry; sea ice; land surface including the carbon cycle; ocean dynamics; and atmosphere dynamics.

ACCESS represents a highly significant milestone initiative carried out jointly by the Bureau of Meteorology and CSIRO, developed through their partnership in the Centre for Australian Weather and Climate Research, with university sector involvement, and support from the Department of Climate Change. Its development commenced in 2005 with a landmark agreement between all Australian participants to cease development of their in-house modelling systems in favour of a single Australian simulator, based on the Unified Model developed by the UK Met Office and obtained under international collaborative arrangements.

A major milestone was reached in September 2009 when the atmospheric dynamical model and its sophisticated real-time data assimilation system were made operational by the Bureau of Meteorology and began providing guidance for weather forecasts out to ten days ahead. Early checks show that the ACCESS forecasts are significantly more accurate than those from the Bureau of Meteorology's old models. Major improvements will follow in 2010 with a doubling of the resolution of the weather prediction models and the application of ACCESS to climate change studies following the successful coupling of the ocean and sea-ice modules to the atmospheric model.

45 Moderate Resolution Imaging Spectroradiometer

Professor Elizabeth Blackburn AC
Image by Howard Moffat/AUSPICt

L to R: Professor Graham Durant (Director of Questacon),
Senator the Hon Kim Carr, Professor Elizabeth Blackburn AC,
Prime Minister Kevin Rudd & Professor Penny Sackett (Chief Scientist for Australia)
Image provided by Questacon

SHOWCASE 2: PROFESSOR ELIZABETH BLACKBURN AC

On 16 February 2010, the Office of the Chief Scientist arranged a day of events in honour of Professor Elizabeth Blackburn AC, Australia's eleventh Nobel Prize winner and the first Australian woman to receive the award. She, along with two of her collaborators, received the 2009 Nobel Prize in Physiology or Medicine for the co-discovery of the molecular nature of telomeres – the ends of eukaryotic chromosomes that serve as protective caps essential for preserving the genetic information – and the ribonucleoprotein enzyme, telomerase. She is now Professor of Biology and Physiology in the Department of Biochemistry and Biophysics at the University of California, San Francisco.

Professor Blackburn was born in Hobart, Tasmania but later moved to Melbourne for high school and university. She earned her B.Sc. and M.Sc. degrees from the University of Melbourne in the early 1970s, and then travelled to Cambridge, where she earned her Ph.D. from the University of Cambridge. Her postdoctoral study in molecular and cellular biology was at Yale University, Connecticut in 1975–77.

Professor Blackburn has received numerous international awards for her research. These include the Australia Prize, which is now known as the Prime Minister's Prize for Science, which she received in 1998, and on Australia Day this year Professor Blackburn was also awarded a Companion of the Order of Australia.

CHAPTER THREE

Business Innovation

Business innovation is crucial to Australia's ability to compete in the global economy and create wealth and prosperity into the future. Innovation in business turns ideas into new products and processes, providing firms with a competitive advantage over low-cost producers in globalised and deregulated markets.

As evidence suggests that innovative businesses record above-average sales growth and profitability, businesses increasingly recognise that continuous innovation is the only sustainable strategy in rapidly changing technological and market circumstances. As economic competition intensifies and globalises, innovation has become more important to businesses of all sizes and in all sectors as they strive to be more efficient and productive with their available resources.

In *Powering Ideas*, the Australian Government sets out its priorities and targets for business R&D and innovation.

Priority 3: The innovation system fosters industries of the future, securing value from the commercialisation of Australian research and development.

Target: The Australian Government aims to see a continuing increase in the number of businesses investing in R&D.

Priority 4: More effective dissemination of new technologies, processes, and ideas increases innovation across the economy, with a particular focus on small and medium-sized enterprises.

Target: The Australian Government's goal is to achieve a 25 per cent increase in the proportion of businesses engaging in innovation over the next decade.

This chapter highlights Australia's performance in business innovation and summarises key achievements and actions addressing these priorities and targets by the Commonwealth and state and territory governments. It also provides case studies showing the importance of innovation to businesses and the significant contribution of universities and PFROs to innovation in business.

Highlights of baseline performance

Innovation activities

Data on innovation activities is collected primarily through national business surveys of innovation and R&D conducted in Australia and other OECD countries. Table 6 provides a summary of how Australia compares with OECD countries in

Table 6: Australia's performance in innovative activities against other OECD countries

Indicators	Latest Figure	Reference Year	OECD Ranking	Gap from the Top Five OECD Performers	Data Source
Number of businesses registered for the R&D Tax Concession*	7,754	2007-08	- [a]	-	(1)
BERD as a % of GDP	1.27%	2007	14th	51.8%	(2)
Proportion of BERD financed by government	3.0%	2007	25th	75.9%	(2)
Tax treatment of R&D in SMEs (The B Index)[46]	0.117	2008	15th	64.6%	(3)
Tax treatment of R&D in large firms (The B Index)[46]	0.117	2008	12th	62.1%	(3)
Total investment in early stage venture capital as a % of GDP[b]	0.054%	2008-09	-	-	(4)
Proportion of innovation-active businesses in Australia*	44.9%	2007-08	-	-	(5)
Proportion of large firms with new-to-market product	12.0%	2002-04	26th [c]	77.2%	(6)
Proportion of SMEs with new-to-market product	7.0%	2002-04	24th [c]	75.6%	(6)
Proportion of non-technological innovators in manufacturing sector	31.7%	2004-06 [d]	15th [e]	47.1%	(3)
Proportion of non-technological innovators in services sector	28.2%	2004-06 [d]	17th [f]	52.7%	(3)

Sources: (1) *Innovation Australia, Annual Report 2008-09*. (2) ABS (2008), *Research and Experimental Development, Businesses, Australia, 2007-08*, cat. no.8104.0; OECD, Main Science and Technology Indicators database, 2009/2. (3) OECD, *Science, Technology and Industry Scoreboard 2009*. (4) ABS (2010), *Venture Capital and Later Stage Private Equity Survey, Australia, 2008-09*, cat. no. 5678.0. Estimated by DIISR. (5) ABS (2009), *Selected Characteristics of Australian Businesses, 2007-08*, cat. no. 8167.0. (6) OECD, *Science, Technology and Industry Scoreboard 2007*.
Notes: Indicators with * and in the coloured rows of the table are the primary indicators applied to measure and monitor progress against the Australian Government's innovation targets. (a) -: Not Available. (b) Early-stage venture capital includes investments in pre-seed, seed, start-up and early expansion. (c) Excludes Mexico, Switzerland, Turkey and the USA. (d) Figures for Australia are for 2006-07. (e) Only nineteen OECD countries are compared including two accession countries. (f) Only eighteen OECD countries are compared including two accession countries.

46 The B-index represents the present value of before tax income needed to cover the initial cost of R&D investment and to pay corporate income tax. Work is ongoing at the OECD to improve the international comparability of countries' R&D tax subsidy rates beyond the B-index.

innovative activities. Australia is ranked among the middle one-third on most indicators, including business expenditure on research and development (BERD), generosity of tax treatment for business R&D, and non-technological innovation such as organisational and marketing innovations. Australia is relatively weak with regard to business R&D directly funded by government and the proportion of firms that develop product innovations which are new to the market, being ranked towards the bottom of the group of OECD countries. Australia's distance from the top OECD countries in innovative activities ranges between 47.1 per cent and 77.2 per cent across these indicators.

The number of companies registered for the R&D Tax Concession provides an estimate of the number of business investing in R&D. This is used as one of the primary indicators to measure and monitor progress against the Australian Government's target of continuing to increase the number of businesses investing in R&D. As shown in Chart 14, the number of companies registered for the R&D Tax Concession recorded an all-time high of 7,754 in 2007-08.

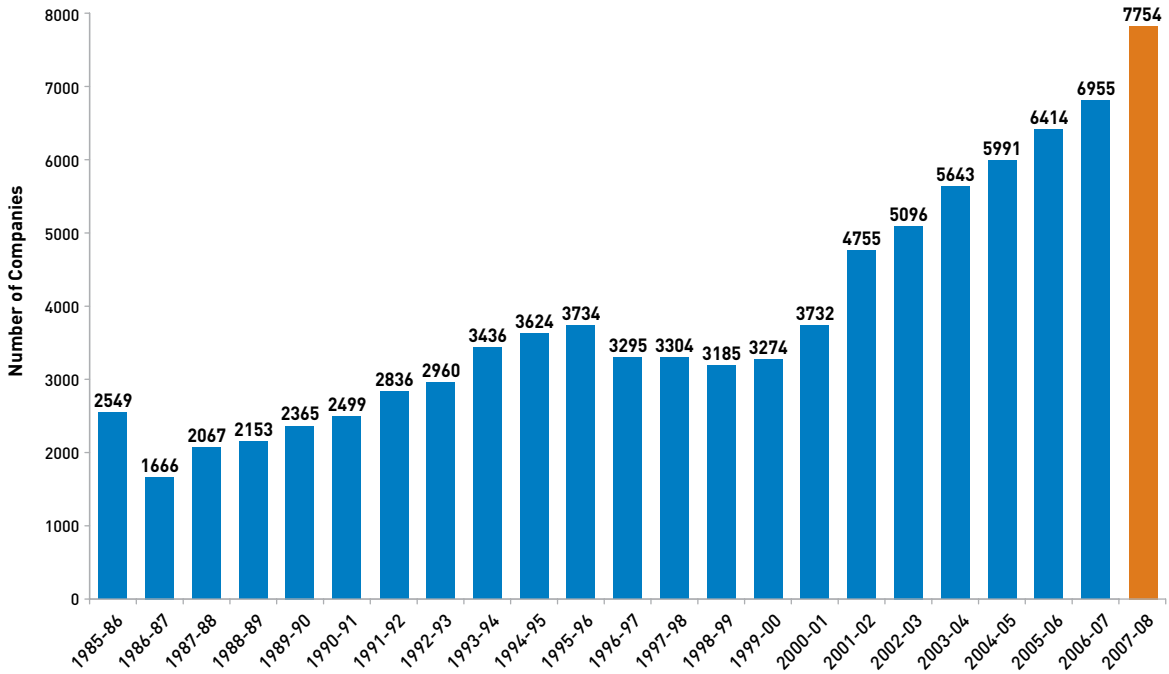
BERD is an indicator of how much importance business attaches to R&D as part of its innovation strategies. Expressing BERD as a percentage of GDP allows a comparison of economies of different size by the intensity of business investment in R&D. In 2007, Australia's BERD amounted to $14.4 billion or 1.27 per cent of GDP. This placed Australia fourteenth out of all thirty OECD countries.

The Australian Government's support for business R&D can be measured by the proportion of business R&D financed by government and the generosity of taxation treatment for R&D expenditure by firms. In 2007, 3 per cent of BERD in Australia was financed by government. This figure was relatively low compared to other OECD countries, ranked twenty-fifth. The B-Index has been developed by the OECD to measure a country's generosity of taxation treatment for business R&D. By this indicator, Australia scored 0.117 in 2008 for both SMEs and large firms, ranked fifteenth and twelfth respectively for OECD countries.

Venture capital investments are generally used to finance start-ups and fast-growing innovative enterprises. Access to venture capital investment is regarded as crucial for growth and employment. Australia's investment in early-stage venture capital (pre-seed, seed, start-up and early expansion) accounted for 0.054 per cent of GDP in 2008-09.

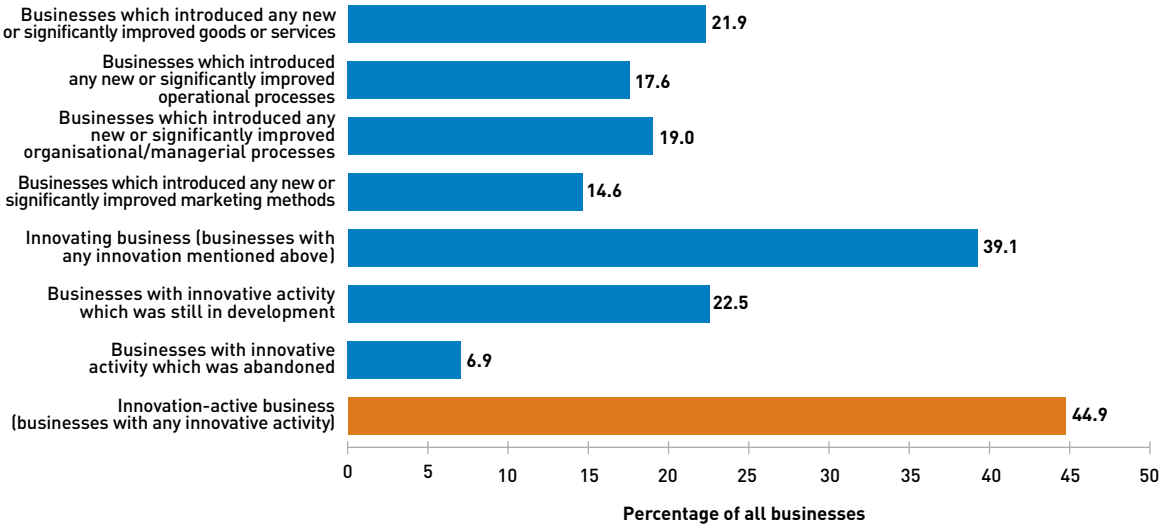
The proportion of innovation-active businesses provides a general estimate of the level of innovation carried out by businesses in a country. This indicator is used to measure and monitor progress against the Government's target of a 25 per cent increase in the proportion of businesses engaging in innovation over the next decade. As shown in Chart 15, innovation-active businesses (those performing any innovative activity) accounted for 44.9 per cent of all businesses in Australia in 2007-08.

Chart 14: Number of companies registered for the R&D Tax Concession, 1985-86 to 2007-08



Source: Innovation Australia, *Annual Report 2008-09*

Chart 15: Innovative activities in Australian businesses, 2007-08



Source: ABS (2009), *Selected Characteristics of Australian Businesses, 2007-08, cat. no. 8167.0.*

The proportion of firms that first develop product innovations which are new to the market or new to the world is a measure of a country's capacity for technological innovation. Over the period 2002-04, the proportion of firms with new to-market products represented 12 per cent of large firms and 7 per cent of SMEs in Australia. This placed Australian businesses at the bottom of the OECD table on this measure, ranked twenty-sixth and twenty-fourth respectively.

Non-technological innovation such as organisational and marketing innovation is an important dimension of many firms' innovative activities. Non-technological innovators comprised 31.7 per cent of all firms in Australia's manufacturing sector and 28.2 per cent of all firms in the services sector. On this measure, in 2002-04, Australia ranked fifteenth out of nineteen OECD countries for the manufacturing sector and seventeenth out of eighteen for the services sector.

Intellectual property

Intellectual property (IP) data has also become one of most widely used resources for constructing indicators of innovative activities. Table 7 shows that Australia is positioned within the middle one-third of thirty OECD countries by all indicators of patenting activities and industrial designs, with the exception of trademark performance, where Australia places in the top one-third. Australia's gaps with the top five OECD countries in intellectual property are slightly higher than those in innovative activities, estimated at between 64.3 per cent and 95.8 per cent across the indicators.

Table 7: Australia's performance in intellectual property against other OECD countries

Indicators	Latest Figure	Reference Year	OECD Ranking	Gap from the Top Five OECD Performers	Data Source
Australian patents granted by IP Australia	1,130	2007	- [a]	-	(1)
Australian designs certified by IP Australia	439	2007	-	-	(1)
Australian trademark applications to IP Australia	43,207	2007	-	-	(1)
Share of world triadic patent families	0.68%	2007	14th	95.8%	(2)
Triadic patent families per million population	16.6	2007	18th	82.1%	(2)
Share of world patent applications filed under PCT	1.33%	2007	12th	90.2%	(3)
Patent applications filed under PCT per million population	66.9	2007	15th	64.3%	(3)
Trademark registrations per million population	1,698	2008	7th	66.3%	(4)
Industrial design registrations per million population	177	2008	13th	77.2%	(4)

Sources: (1) IP Australia, *IP Statistics*. (2) OECD, Main Science and Technology Indicators database, 2009/2. (3) OECD, Online Patent database. (4) World Intellectual Property Organization (WIPO), WIPO Statistics database, February 2010.
Notes: (a) -: Not available.

In 2007, IP Australia granted 1,130 patents and certified 439 designs to Australian residents. In the same year, 43,207 trademark applications were filed with IP Australia by Australian residents.

Data on triadic patent families (complementary patents filed in Europe, the United States and Japan) and patent applications filed under the Patent Cooperation Treaty (PCT) allow an international comparison of inventive activities across OECD countries. In 2007, Australia accounted for 0.68 per cent of total world triadic patent families, ranked fourteenth among OECD countries. With 16.6 triadic patent families per million inhabitants, Australia ranked eighteenth in the OECD.

Australia performs slightly better on the measure of patent applications filed under the PCT. In 2007, Australia accounted for 1.33 per cent of total world patent applications filed under PCT, with 66.9 patent applications filed under PCT per million of population, placing Australia twelfth and fifteenth respectively in the OECD.

Data on industrial designs and trademarks can be informative about innovation performance as a proxy for product innovation and marketing innovation. Industrial designs and trademarks are often associated with the commercial launch of new products and related to firms' brand and marketing strategies. In 2008, Australia recorded 1,698 trademark registrations and 177 industrial design registrations per million of population, ranked seventh and thirteenth respectively among OECD countries.

Innovation outputs and outcomes

Innovation is motivated by the prospect of economic and social benefit. This section briefly considers some indicators of how innovation contributes to such benefits.

Table 8 shows that Australia's performance in terms of innovation outputs and outcomes is mixed. Australia is in the top one-third of OECD countries for knowledge-intensive market services, GDP per capita, and human development. Australia falls to the middle one-third, however, on indicators of labour productivity and global competitiveness, and to the bottom one-third when it comes to high and medium-high technology manufacturing, high and medium-high technology manufacturing exports, exports in goods and services, and environment performance. Australia is between -0.19 per cent and 91.2 per cent from the top five OECD performers.

Table 8 Australia's performance in innovation outputs and outcomes against other OECD countries

Indicators	Latest Figure	Reference Year	OECD Ranking	Gap from the Top Five OECD Performers	Data Source
Share of high and medium-high technology manufacturing in total gross value added	3.0%	2004	25th [a]	76.5%	(1)
Share of knowledge-intensive market services in total gross value added	23.2%	2004	5th [a]	13.2%	(1)
Share of high and medium-high technology in manufacturing exports	27.4%	2007	28th	64.8%	(2)
Exports in goods as a % of GDP	17.7%	2007	26th [b]	75.4%	(3)
Exports in services as a % of GDP	5.1%	2007	24th [b]	91.2%	(3)
GDP per capita relative to the USA (USA=100)	83	2008	8th	28.1%	(4)
GDP per hour work (USA=100)	82	2008	12th	28.1%	(4)
World ranking by the Global Competitiveness Index	15th	2009-10	12th	6.6%	(5)
World ranking by the Human Development Index	2nd	2007	2nd	-0.19%	(6)
World ranking by the Environment Performance Index	51st	2010	24th	23.2%	(7)

Sources: (1) OECD, *Science, Technology and Industry Scoreboard 2007*. (2) OECD, *Science, Technology and Industry Scoreboard 2009*. (3) OECD, *OECD in Figures 2009*. (4) OECD, OECD Productivity database, October 2009. (5) World Economic Forum, *The Global Competitiveness Index 2009-2010*. (6) The United Nations Development Programme, *Human Development Report 2009*. (7) Yale University and Columbia University, in collaboration with the World Economic Forum and the Joint Research Centre of the European Commission, *Environment Performance Index 2010*.
Note: (a) Excludes Turkey. (b) The figures are derived by DIISR from the OECD source based on data on exports in goods and services and GDP in billion US dollars, current prices and PPPs.

The shares of high and medium-high technology manufacturing and knowledge intensive market services in total gross value added (GVA) provide a proxy measure of the importance of technology and knowledge to the economy. In 2004, Australia ranked at the low end of OECD countries (twenty-fifth) for the share of high and medium-high technology manufacturing in total GVA (3 per cent) but at the high end (fifth) for the share of knowledge-intensive market services in total GVA (23.2 per cent).

The share of high and medium-high technology in manufacturing exports provides a measure of a country's participation in global high-technology markets, which is regarded as important to overall competitiveness in the world economy. High and medium-high technology products accounted for 27.4 per cent of total manufacturing exports for Australia in 2007. By this indicator, Australia ranked twenty-eighth, towards the bottom of OECD countries.

Exports in goods and services are used to estimate a country's capacity to develop new knowledge and transform it into goods and services that can be sold abroad. In 2007, Australia's exports in goods and services accounted for 17.7 per cent and 5.1 per cent of GDP, ranked twenty-sixth and twenty-fourth among OECD countries, respectively.

GDP per capita and per hour worked relative to the USA enable international comparisons of a country's living standards and labour productivity. In 2008, Australia scored 83 for GDP per capita and 82 for GDP per hour worked relative to the USA (indexed at 100), ranking Australia eighth and twelfth respectively, among OECD countries.

The Global Competitiveness Index (GCI) provides an assessment of the medium- to long-term productivity and growth prospects of national economies. Rankings are calculated from publicly available data and the Executive Opinion Survey, a comprehensive annual survey conducted by the World Economic Forum together with its network of partner research institutes and business organisations in the countries covered by the *Global Competitiveness Report*. For 2009-10, the GCI ranked Australia fifteenth in the world and twelfth out of OECD countries.

The Human Development Index (HDI) combines normalised measures of life expectancy, educational attainment, and GDP per capita for countries worldwide. It is a means of standardising the measurement of human development – a concept that, according to the United Nations Development Program, refers to the process of widening the options of persons, giving them greater opportunities for education, health care, income, employment, and so on. On this measure, Australia ranked second only to Norway in 2007, both in the world and among OECD countries.

The Environmental Performance Index (EPI) is a method of quantifying and numerically benchmarking the environmental performance of a country's policies. This index was developed by Yale University and Columbia University in collaboration with the World Economic Forum and the Joint Research Centre of the European Commission. On this measure, Australia ranked fifty-first in the world in 2010 and twenty-fourth among OECD countries.

Fostering industries of the Future

Achievements and actions by the Australian Government

Supporting business R&D

R&D Tax Credit

In the 2009-10 Budget, the Australian Government announced it would replace the existing R&D Tax Concession with a new, more streamlined R&D tax incentive from 1 July 2010. The two core components of the new incentive are a non-refundable 40 per cent standard R&D Tax Credit; and a 45 per cent refundable R&D Tax Credit for companies with a turnover of less than $20 million. Eligibility for the new R&D tax incentive will be more targeted to ensure the best possible return on taxpayers' investment.

The new R&D Tax Credit will allow businesses to invest knowing that they can claim a tax credit of at least 40 per cent of their expenditure on eligible R&D. Further, the refundable R&D Tax Credit will enable more small innovative firms to get an immediate contribution towards their R&D.

A consultation paper on the new R&D tax incentive was released for public comment in September 2009. Public consultation sessions were held in major capital cities during September and October. Submissions on the paper closed at the end of October. Exposure draft legislation was released for public comment in December, and comments were invited by 5 February 2010. Legislation is expected to be introduced into Parliament in 2010 to ensure that the Tax Credit will be available for income years starting on or after 1 July 2010.

The Automotive Competitiveness and Investment Scheme

The Automotive Competitiveness and Investment Scheme (ACIS) is directed toward encouraging new investment and innovation in the Australian automotive industry. ACIS rewards production, investment and R&D through the quarterly issue of import duty credits to registered participants. The scheme commenced on 1 January 2001 and will conclude on 31 December 2010.

Capped assistance has been limited to $2 billion over the period 2006-10. Supply chain participants can earn 45 per cent of the value of investment in R&D while motor vehicle producers (MVPs) can claim similar benefits when they act as producers of components, tools or services for third parties. The capped element of ACIS also includes the MVP R&D Scheme which encourages Australian MVPs to invest in high end R&D technologies, offering up to $150 million in R&D assistance from 2006 to 2010.

From 2011, ACIS will be replaced by the $3.4 billion *Automotive Transformation Scheme* which will operate over the period 2011-20.

Support for research commercialisation

Commercialisation Australia

Commercialisation Australia structures support around the key stages in the commercialisation process. Its objective is to help researchers, individuals and innovative firms convert their ideas into successful commercial ventures. Commercialisation Australia has funding of $196.1 million over the four years to 2012-13, with ongoing funding of $82 million a year thereafter.

The Commercialisation Australia board was named on 9 February 2010. The board assists with the administration of Commercialisation Australia, ranking applications on merit and advising on the strategic direction of the program.

Commercialisation Australia offers an integrated suite of assistance measures tailored to the needs of each successful applicant.

- *Skills and Knowledge* gives participants access to specialised advice and services to build the skills, knowledge and links required to commercialise new ideas. This includes funding of up to $50,000 to engage specialist services.
- *Experienced Executives* offers funding up to $200,000 over two years to engage an experienced chief executive officer or other executives. This will help give small innovative firms and people new to business the experienced management skills they need.
- *Proof-of-Concept* grants provide funding of up to $250,000 to assist with testing the commercial viability of a business model or idea for a product, process or service.
- *Early Stage Commercialisation* grants provide funding from $250,000 to $2 million to support activities focused on enabling a new product, process or service to be developed to the stage where it can be taken to market. The grants are repayable on success of the project.

Applications to Commercialisation Australia opened on 4 January 2010 and are accepted and assessed continuously.

Driving eco-innovation

Clean Business Australia

As part of the 2008-09 Budget, the Australian Government announced the Clean Business Australia partnership with business and industry to deliver energy- and water-efficient projects with a focus on productivity and innovation. It has three elements.

The Climate Ready Program is a competitive grants program which aims to support the development and commercialisation of innovative products, processes and services that address the effects of climate change. Since the program opened for applications on 28 July 2008, a total of $78.7 million in funding has been granted to 105 projects.

Re-tooling for Climate Change supports efforts by Australian manufacturers to reduce their environmental footprint through projects that improve the energy- and water-efficiency of production processes. The total value of grant offers approved to date is $14.58 million for seventy-two projects.

The Green Building Fund aims to reduce the greenhouse impact of Australia's built environment by reducing the energy consumed in the operation of commercial office buildings. The total value of approved grants from the first four rounds is $55.2 million, supporting investment of $218 million on 156 projects for the upgrade of buildings and two projects to develop industry capability. The predicted green house gas savings arising from the approved projects is more than 127,000 tonnes of CO_2 (or its equivalent) per annum.

Green Car Innovation Fund

The Green Car Innovation Fund (GCIF) is a key element of the Australian Government's *New Car Plan for a Greener Future* announced in November 2008.

The GCIF is a competitive grants program that will provide $1.3 billion over ten years to Australian companies. Stream A provides grants from $5 million upwards for motor vehicle producers (MVPs), while Stream B provides grants from $100,000 for other Australian companies and individuals, including researchers. Grants are generally provided at a ratio of one dollar of government funding for every three dollars of eligible expenditure contributed by the grantee.

The GCIF supports R&D, proof-of-concept, early-stage commercialisation and pre-production development activities undertaken in Australia. Grants have so far been awarded to the three MVPs (Ford, Holden, Toyota), and one component supplier (Orbital).

Carbon Pollution Reduction Scheme

The Carbon Pollution Reduction Scheme (CPRS), Australia's primary policy tool for reducing greenhouse gas emissions, will be a mandatory cap-and-trade emissions trading scheme, setting a limit on the total quantity of greenhouse gases that can be emitted from designated sources. The introduction of a carbon price through the CPRS will change the relative prices of goods and services, making emissions-intensive goods more expensive relative to those that are less emission-intensive. This provides a powerful incentive for consumers and businesses to adjust their behaviour and will drive innovation in low-emissions technologies.

The CPRS is scheduled to commence on 1 July 2011 and will be ongoing. The Australian Government will specify CPRS caps for at least five years in advance. In addition, up to a further ten years of guidance will be provided through the establishment of gateways or ranges within which future CPRS caps will lie.

The $1.97 billion Climate Change Action Fund will smooth the transition to a low-pollution economy by providing targeted assistance to business, community sector organisations, workers, regions and communities. In particular, the fund will support a new Innovation in Climate Change Program, which will provide competitive grants to drive the development and application of low-emission production methods, supply-chain improvements, products and services, and encourage investment in energy-saving projects with long pay-back periods.

Renewable Energy Target

The Australian Parliament passed government legislation on 20 August 2009 to implement the expanded national Renewable Energy Target (RET) scheme, designed to ensure that 20 per cent of Australia's electricity supply comes from renewable sources by 2020. This means that in ten years time the amount of electricity coming from solar, wind, geothermal and other renewable sources will be about equal to Australia's current household electricity use.

The RET scheme will conclude in 2030, by which time the CPRS is expected to be the primary instrument for driving the take-up renewable energy. The RET will provide a significant boost to the renewable energy industry. Modelling shows that implementation of the expanded RET, together with the CPRS, should drive around $19 billion in investment in the renewable energy sector in the decade to 2020.

Clean Energy Initiative

The $4.5 billion Clean Energy Initiative (CEI) announced in the 2009-10 Budget complements the Carbon Pollution Reduction Scheme and Renewable Energy Target by supporting R&D and the demonstration of low-emission and renewable energy technologies, including industrial-scale carbon capture and storage (CCS) and solar energy. The CEI has three main components.

The Solar Flagships Program aims to accelerate the commercialisation of solar power in Australia by supporting the construction and demonstration of up to four large-scale solar power plants using solar thermal and photovoltaic technologies. Launched on 11 December 2009, the program has funding from 2009 to 2015. The first selection round in 2010 will select one solar thermal and one photovoltaic project, with a target of 400 MW of combined generation capacity across both projects. The second selection round is planned for 2013-14, following a review of the outcome of round one.

The Carbon Capture and Storage Flagships Program will run from 2009 to 2018 to support the construction and demonstration of large-scale integrated carbon capture and storage projects in Australia as part of the widespread deployment of CCS technology from 2020. CCS Flagship projects are expected to be industrial-scale demonstrations that will contribute to the overall target of 1,000 MW of low-emissions fossil fuel power generation. The Australian Government expects to announce successful projects in the second half of 2010.

Australian Centre for Renewable Energy will promote the development, commercialisation and deployment of renewable technologies. The initiative has new funding for 2009-10 to 2013-14, with some projects extending beyond this period. It will support focused, collaborative, high-priority technology research, with the ultimate aim of progressing new technologies and lowering the cost of existing technologies.

Achievements and actions by state and territory governments

Tasmania

Springboard Accelerator Program – Business Incubation Services

The Springboard Accelerator Program aims to accelerate the commercialisation of science and technology businesses' products and services. The program provides hands-on management, consulting, training, mentoring and recruitment assistance and funding to start-up businesses and SMEs. Incubation services are delivered to regional centres through a combination of virtual and physical incubation facilities.

Between 2007 and 2010, the program received more than 145 individual expressions and spent $2.4 million to help twenty-two firms. All firms have expressed a high level of satisfaction with the business planning, marketing and commercialisation advice and assistance they have received.

Australian Capital Territory

InnovationConnect

InnovationConnect is an initiative that provides creative innovators and entrepreneurs with small grants to support the development and commercialisation of viable, creative ideas. This initiative fills the funding gap facing early-stage innovative companies in the Australian Capital Territory as they seek to develop products or services to the stage of investment readiness or commercialisation.

The program is funded by the ACT Government over a period of three years from 2007-08. To date, the program has supported thirty-six projects of which twenty-six were for proof-of-technology and the remainder were projects to accelerate innovation. The grants have ranged from a few thousand dollars to around $50,000 per project. The program continues to grow and has received sixty-seven applications since September 2008.

South Australia

Trans Tasman Commercialisation Fund

The Trans Tasman Commercialisation Fund (TTCF) is a collaboration between leading universities in south-eastern Australia and New Zealand, supported by capital provider Westscheme, Western Australia's largest non-government superannuation fund. These parties have come together with the common goal of generating strong returns by investing in the commercial application of research results. TTCF invests seed capital in early commercial research projects and spinout companies generated by member universities.

The South Australian Government helps meet the operating costs of the TTCF in South Australia to encourage collaboration between the technology transfer offices of the three local universities, strengthen commercialisation skills, and leverage the State Government's investment in R&D by commercialising intellectual property.

Increasing innovation across the economy

Achievements and actions by the Australian Government

Improving business access to ideas and technologies

Enterprise Connect

Enterprise Connect, established in 2008, is a $50 million a year initiative that connects SMEs to new skills, ideas and technologies, helping them to become more innovative, efficient and competitive.

Enterprise Connect provides a range of services and support to help firms build their internal capacity and capability. The core services include:

- a Business Review conducted by a highly skilled business adviser at no cost to the firm
- the Tailored Advisory Service (TAS), which provides matching funding of up to $20,000 to implement actions identified in the Business Review
- Client Management, which is an ongoing advisory service for all client firms for up to twelve months following a Business Review
- Researchers in Business (RiB), which helps place researchers from universities or PFRAs with businesses to develop and implement new commercial ideas
- Workshops Industry Intelligence and Networking (WIIN), which provides firms with access to events and networking opportunities relevant to their sector
- Technology and Knowledge Connect (TKC), which provides technology and technical knowledge advice
- Technology Partnerships Equipment Register (TPER), which provides firms with access to leading-edge equipment.

A national network of Enterprise Connect centres and a team of highly skilled business advisers deliver these services in various locations, including regional and remote locations.

Achievements of Enterprise Connect from its establishment to 31 December 2009 include:

- 2,169 applications for *Business Reviews* approved, with 1,709 reviews completed
- 778 applications by 668 firms for TAS grants approved, with 295 TAS projects completed
- nineteen RiB projects and eleven WIIN grants approved
- 118 companies assisted through TKC
- twenty-eight pieces of specialist equipment in fifteen companies registered under the TPER.

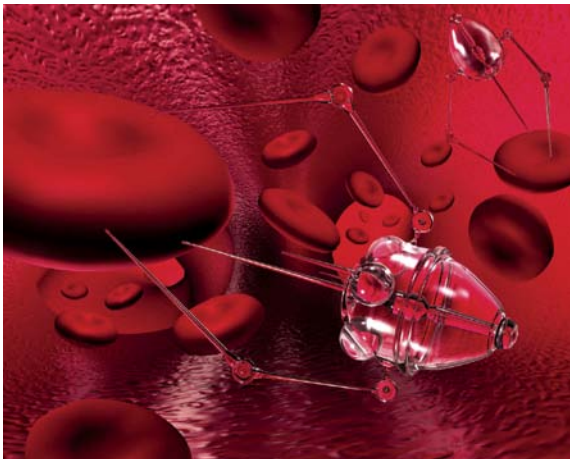


Image provided by Plantic Technologies Limited

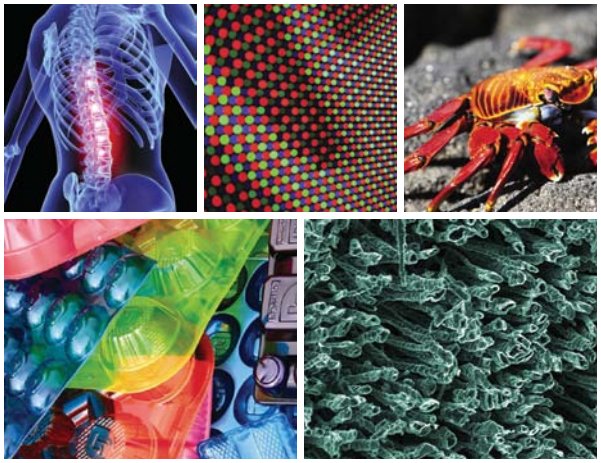


Image provided by the Australian National University

National Enabling Technologies Strategy

The National Enabling Technologies Strategy has funding of $38.2 million over four years. The strategy provides a framework for the responsible development of nanotechnology and biotechnology and other enabling technologies as they emerge in Australia. It will help Australian industries capitalise on growth opportunities and ensure Australia can benefit from enabling technologies while addressing any risks to health, safety and the environment, and potential social and ethical impacts.

The strategy was announced on 22 February 2010. It argues for:

- a national approach (supported by a Stakeholder Advisory Council)
- balancing risk and reward (through policy and regulation)
- developing measurement capabilities
- engaging with the public
- using technology for a better future (including by promoting industry uptake)
- preparing for the future (including through foresighting activities).

Improving businesses access to venture capital

Innovation Investment Fund

The Innovation Investment Fund (IIF) is a venture capital program that supports fund managers to invest in early-stage companies commercialising Australian R&D and enables private sector investors to leverage off public equity capital. By demonstrating the returns achievable from investing in such companies, the IIF aims to encourage additional private sector investment.

The objectives of the IIF program are to:

- develop fund managers with experience in the early-stage venture capital industry
- encourage the growth of new companies that are commercialising R&D by addressing capital and management constraints
- create, in the medium-term, a self-perpetuating funding pool
- develop a self-sustaining, early-stage venture capital industry in Australia.

Round 1 (IIF1) commenced in 1998 and supports five licensed private sector fund managers. Round 2 (IIF2) was announced in 2000, with four licensed fund managers commencing operations in 2001.

All funds operate for a period of ten years, with an additional three years for orderly divestment of investments if required. The Australian Government has invested $221 million in Rounds 1 and 2, which has been matched with $133 million from the private sector.

Round 3 (IIF3) of the program was announced in 2006, with the Government committing up to $200 million to license up to ten fund managers in five consecutive tranches. The Government will provide up to $20 million in capital to each venture capital fund, which, as a minimum, must be matched one to one with privately sourced capital.

Two funds have been licensed under Tranche 1 of IIF3 and a further two under Tranche 2. Tranche 3 of the program was announced on 26 February 2010 and will close on 31 May 2010. To date, IIF3 has committed $170 million (Australian Government plus private sector capital) to the early-stage venture capital sector in Australia.

Innovation Investment Follow-on Fund

The Australian Government's Innovation Investment Follow-on Fund (IIFF) is a temporary, targeted and timely response to the lack of venture capital available to the most promising innovative companies during the GFC. The fund is enabling these early-stage companies to go on growing and commercialising research.

The IIFF program was open to fund managers which had established relationships with the Government through the Innovation Investment Fund, the Pre-Seed Fund, the Renewable Energy Equity Fund or the ICT Incubator Program. Investments were restricted to investee companies already supported by these programs. Outcomes of the IIFF selection round were announced on 6 August 2009. Eleven managers were successful, with a collective portfolio of thirty-five investee companies (including one co-investment). Total IIFF expenditure proposed is $64.4 million. As of March 2010, $29.7 million has been drawn down.

Protecting intellectual property

Improving the IP System

In 2008-09, IP Australia embarked on an IP rights law reform project, incorporating proposals from the Advisory Council on Intellectual Property, the Australian Law Reform Commission and *Powering Ideas*. The reform project aims to reduce barriers to innovation facing researchers and inventors, improve certainty about the validity of granted patents, and allow faster processing of patent claims.

The proposals were canvassed in seven discussion papers, with a second round of consultation commencing in December 2009. If the proposed changes are adopted into law, patent standards in Australia will be better aligned with standards in other jurisdictions, which will provide greater certainty to Australian innovators about the robustness of their Australian patents and their ability to export their inventions.

Higher patent thresholds will also benefit Australian innovators who wish to pursue follow-on innovations involving patented technology; overly broad patents can hurt the country's overall innovation effort by limiting the freedom of subsequent innovators to operate. Higher thresholds will also ensure that Australian consumers do not pay more for technology than is paid elsewhere.

Building an innovation culture

Industry Innovation Councils

The Industry Innovation Councils are part of the Australian Government's innovation agenda for the twenty-first century, as detailed in *Powering Ideas*. The councils contribute to transforming industry in Australia by building a strong innovation culture. There are seven councils, covering the automotive; built environment; future manufacturing; information technology; space; steel; and textile, clothing and footwear industries. They:

- provide strategic advice on innovation priorities to the Minister for Innovation, Industry, Science and Research
- champion innovation in industry
- build connections and collaborate across councils and with other innovation initiatives.

The councils bring together people, from industry, unions and professional organisations, science and research agencies, and government – many for the first time. The councils actively engage with stakeholders and collaborate on projects and initiatives with organisations across the innovation system. These include Enterprise Connect, Cooperative Research Centres, National ICT Australia, CSIRO, the Industry Capability Network, individual firms and industry associations, universities, and Commonwealth, state and territory governments.

Outputs to date include an automotive technology roadmap (due for completion in April 2010), reports on Australia's innovative capacity and capability, and a self-help innovation quiz. Councils are examining strategic priorities in the national innovation system, including clean technology manufacturing opportunities, best practices in leading and managing systematic innovation in firms, and innovative practices in Australia's built environment sector to inform construction of the sustainable cities of the future.

To champion innovation, twenty-five members of five councils have shared their experiences as innovation leaders in a multimedia publication called Innovation Profiles. The *Innovation Profiles* are real stories of innovation in Australian industry, available in video, web and print formats.

Achievements and actions by state and territory governments

South Australia

Innovate SA

Innovate SA is tasked with fostering innovation and growth among emerging and established South Australian businesses. It is substantially funded by the South Australian Government but operates as an incorporated entity at arms-length from government. It assists businesses looking to develop innovative products, services, processes and business models through the provision of high quality targeted educational workshops and seminars, independent business advice and mentoring, detailed diagnostic services, case management, and referrals to match business needs with solutions.

As an independent organisation, with twenty-three staff possessing high level expertise, considerable private sector experience and well developed networks, Innovate SA is able to deal with CEOs, business owners and managers to set their businesses on the right growth path, unlocking doors to global markets and the path to business sustainability. Innovate SA aims to assist 2,000 local enterprises in its first year.

Queensland

Ulysses – Transforming Business through Design

Ulysses – Transforming Business Through Design was launched in 2009 under the Designing Queensland Program, part of the Queensland Government's *Smart State Strategy: Queensland's Smart Future 2008-12*, to make Queensland's mainstream businesses internationally competitive through design.

The *Ulysses* program will operate over three years from 2009-12 and is based on the New Zealand Government's highly successful *Better by Design*, which exceeded its goal of helping fifty companies grow at five times the rate of New Zealand GDP and contribute a total of $500 million in additional export revenue in five years. Ulysses was developed in partnership with international experts Equip Design Integration Consultants and delivery of the program has been contracted to QMI Solutions. Ulysses will be trialled in early 2010.

Victoria

Beyond 2020 (Victorian Technology Roadmap Project)

The focus of the Victorian Government's Beyond 2020 initiative is to systematically examine emerging and prospective science, technology and innovation issues out to 2020 and beyond. The aim is to determine which are critical drivers of innovation and productivity – and therefore economic growth – and their likely implications for Victoria.

As a first step in Beyond 2020, the Victorian Government has started work on the Victorian Technology Roadmap Project. The project began in April 2009 and will deliver a series of detailed and dynamic technology roadmaps for key Victorian industry sectors and cross-sectoral capabilities looking out to 2020, including specific policy recommendations.

Western Australia

Innovator of the Year

Western Australia's Innovator of the Year Awards program was designed to promote a culture of innovation and entrepreneurship across the state's public, private and educational sectors. The program celebrates the creative minds of many Western Australians and targets products and services at the pre-commercialisation stage. The awards aim to build links between industry and research, expand the State's export potential and showcase Western Australian capability. A range of prizes are awarded including business skills training, mentoring and financial assistance. The program also includes a schools component to encourage innovation within the school system and to provide students with an insight into how promising new ideas are identified and commercialised.

CASE STUDIES: BUSINESSES

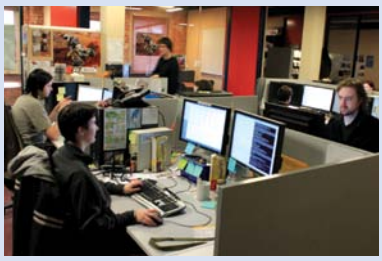
Deloitte Touche Tohmatsu

Deloitte Touche Tohmatsu employs 4,600 people in Australia who provide audit, tax, consulting, and financial advisory services to public and private clients. In 2009, the firm achieved revenue growth of 11 per cent in spite of the toughest trading conditions in decades and after maintaining growth rates of more than 20 per cent for the three previous years.

Deloitte's innovation program and its cluster-based growth strategy have been keys to its success. During the GFC, the cluster-base growth strategy - breaking the business into more than 60 clusters and sub-groups - has enabled performance management at a granular level, adept resource distribution and decisive action.

Deloitte's program has supported the development of new products and services, enabling the company to make the most of new opportunities. The opportunity to become more attractive than its competitors, to grow and gain market share and outstrip the competition were seen as good reasons at Deloitte to spend more on innovation.

Deloitte has recognised that innovation is a pathway to bringing greater ingenuity and efficiency to the company's market performance with clients. To this end, Deloitte started a program to encourage people to explore innovative ways of thinking and apply different perspectives to solving business issues. More than 2,000 employees regularly collaborate on the in-house social media channel, while an equal number attend service line and national client-focused idea cafés and workshops aimed at complex problem-solving and creating opportunities in the marketplace. The premise is that everyone is an innovator. Deloitte's response to its challenges of growth has been an innovation program that is transforming the work environment at the deepest level.



Tantalus Media Pty Ltd
Image by Geoff Ellis

Tantalus

With fifteen years in the business and a portfolio of over 30 titles on most major videogame platforms, Tantalus is one of the world's leading independent development studios. The company, which specialises in handheld development, is an Australian business-to-business export success with a reputation for developing high-quality titles for clients, including some of the largest global entertainment companies. Examples of recent success include *Pony Friends* and *Cars Mater-National*, which have both sold over one million units on the Nintendo DS platform.

The company places particular value on innovation, with R&D undertaken in-house by world-class software engineers. Continually investing in cutting-edge R&D has translated to a standard of proprietary technology that facilitates rapid development and provides a high level of graphic fidelity in the final product. Tantalus games are consistently regarded as technically impressive by the consumer press and by international publishing partners.

The company has played a key role in growing a highly skilled local creative industry. From 2007 to 2009, Tantalus expanded its full-time staff by 33 per cent to 80 employees while also outsourcing 10 per cent of development resources to other Australian game developer businesses.

The focus of the company over the past year has been the transition to new videogame platforms, specifically the Nintendo Wii. In 2009 Tantalus released follow-up titles in the *Cars* and *MX* vs *ATV* franchises, along with *Pony Friends 2* on Nintendo DS, Wii and PC.

Aqua Diagnostic[47]

Aqua Diagnostic is based in Melbourne and markets a range of products using the company's PeCOD technology to enable chemical oxygen demand (COD) analysis in the field, laboratory and online without the need for hazardous chemicals. It is the first company in the world to commercially deploy a nanotechnology based photo-electrochemical technology for the analysis of COD.

The technology was developed by a leading group of photo-electrochemical researchers at Griffith University and spun-out into a business in 2005 with the financial backing of SciVentures Investments, a Pre-Seed Fund manager. Aqua Diagnostic has received support through AusIndustry's Commercial Ready and Climate Ready programs to develop its products.

Aqua Diagnostic is building export sales globally, with particularly strong interest in North America, the UK, China and Taiwan. Over the last four years, Aqua Diagnostic has engaged Austrade to assist with introductions to potential partners. In building its export business, the company is establishing a number of key customer reference sites for its products in each country, and building relationships with regulatory agencies and government bodies, as well as supporting its partner network with training and technical support. The company continues to develop the R&D program for its next generation of products in response to market feedback.

Aqua Diagnostic was recognised in the Science Innovation category of the 2008 Fast Thinking-Open Universities Innovation Awards. Its product, the PeCOD L100 COD Analyser, also received an award at the IBO 2008 Industrial Design Awards.

47 Case study provided by the Australian Trade Commission.

Professor Anton van den Hengel, Director of the University of Adelaide's Australian Centre for Visual Technologies and Snap co-founder.
Image by Jennie Groom

CASE STUDIES: UNIVERSITIES

Surveillance software solves security snag

Sophisticated network surveillance technology developed at the University of Adelaide will help solve a security dilemma facing airports, casinos, central business districts, shopping malls and large sporting and entertainment venues around the world. The new software will automatically integrate data from thousands of security cameras in a video surveillance network into a single sensor, eliminating existing problems with huge information overloads.

Developed at the University's Australian Centre for Visual Technologies, the software is being commercialised by Snap Network Video Surveillance Pty. Ltd., a university spin-out company funded with a major investment from the Trans Tasman Commercialisation Fund (TTCF). Snap has received equity funding of $500,000 from TTCF, a $30 million venture collaboration of South Australia's three public universities, Monash University in Victoria and the University of Auckland in New Zealand. It has also received capital funding from the WA-based industry superannuation fund *Westscheme* and support from the South Australian, Victorian and New Zealand governments.

Dr Henry Detmold, Snap's chief technology officer and co-founder, says this patented technology will provide significant benefits to large-scale surveillance applications in Australia and internationally. The technology has applications across the full spectrum of large-scale video surveillance, including casinos, airports and the 2012 London Olympics. Robert Chalmers of Adelaide Research & Innovation, the University's commercial development company, says the video surveillance software is an "exciting development for the University of Adelaide, reinforcing its reputation as a hub of world-class research and innovation".

Ofidium

Ofidium is a promising Melbourne-based telecommunications start-up company founded by Monash University and Professor Arthur Lowery to commercialise technology invented by Lowery and his Monash colleague Professor Jean Armstrong. Lowery and Armstrong combined their world-leading expertise in optical-fibre and wireless communication to devise a new optical-fibre transmission technology based on the dominant wireless transmission scheme. This work was protected by a series of patent applications filed by Monash. The invention, optical orthogonal frequency-division multiplexing (OFDM), won the $100,000 Peter Doherty Prize for Innovation in 2006 as well as a host of other awards.

After this success attracted the attention of Melbourne-based investor Starfish Ventures, a Pre-Seed Fund manager, Ofidium was incorporated in December 2007, with a small cash investment from Starfish and support from Monash. In February 2008, Jonathan Lacey, a colleague of Lowery's in the Australian Photonics CRC in the 1990s, returned from a decade in Silicon Valley to be Ofidium's CEO. Ofidium's $6 million Series A funding round, led by Starfish, closed in September 2008. A subsequent top up was provided by the Trans-Tasman Commercialisation Fund, a seed investor co-founded by Monash to invest in start-up opportunities like Ofidium. Backed by this strong investor support, the company is developing products that will enable the next generation of long-distance optical fibre telecommunications systems, such as those required for Australia's National Broadband Network. Five market-leading telecommunications network equipment manufacturers, based in North America and Europe, are testing Ofidium's technology demonstration in 2010.

Image provided by QRxPharma Limited

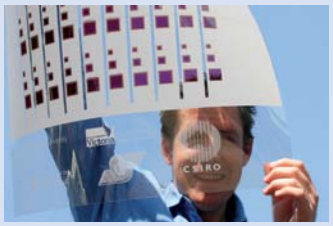
QRxPharma Limited

QRxPharma was established in 2002 by the University of Queensland's commercialisation company, UniQuest, to commercialise pain-management and cardiovascular health technologies developed by researchers Professor Maree Smith, Associate Professor Fraser Ross, Dr Paul Masci, Professor Martin Lavin, Professor John de Jersey, and Associate Professor Lindsay Brown.

Australian and international venture capital of $10 million was secured from Innovation Capital, Nanyang Ventures (an Innovation Investment Fund manager), SpringRidge Ventures, and Uniseed. This represented possibly the largest first round investment for any Australian start-up company. It funded the development of the company and its most advanced drug candidate, the dual opioid pain therapy, MoxDuo.

With the completion of Phase II trials in the USA and Federal Drug Administration approval to start Phase III clinical trials, QRxPharma was floated in 2007 to raise the necessary funds. The company listed on the Australian Securities Exchange and, with twenty-five million shares, raised $50 million, with an initial market capitalisation of $150 million. It set an Australian record as the largest biotech initial public offering (IPO) on the exchange to date, and also the largest biotech capital raising at an IPO. A second $21.6 million capital raising in 2009 was designed to further support the company's plans for launching MoxDuo in the US in 2011.

Also in 2009, QRxPharma established a joint venture with a Chinese partner, Liaoning Nuokang Medicines Co Ltd, to develop the commercial potential of two snake-venom based discoveries. The investment of US$5 million in QRxPharma's venomics assets led to the formation of Venomics Pty Ltd and Venomics Hong Kong Limited, which has operations in China.



Dr Scott Watkins with a sample of thin film flexible solar cells.

Dr Gerry Wilson (left) with Flagship Director Mr Clive Davenport (right) during printing trials at Securency International. *Images provided by CSIRO*

CASE STUDIES: PUBLICLY FUNDED RESEARCH ORGANISATIONS

Printable Solar Cells

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) is working with the Victorian Organic Solar Cell Consortium (VICOSC) to trial flexible, reel-to-reel printable plastic solar cells. This research is at the forefront of polymer technology and is an exciting development for the solar industry in Australia.

The solar cells are printed onto polymer in much the same way as polymer banknotes are made. Printable solar cells have several advantages over traditional solar panel technology, including the potential to mass produce cells cheaply and install them over large areas such as rooftops. The technology for the solar cells was the result of work by CSIRO researchers on advanced polymers.

The project has progressed past its halfway point and printing trials by Securency International, a banknote printing company, began six months ahead of schedule. While the technology used for these cells is still in its infancy, this project aims to speed up the development of this technology to take it from research to practical use as quickly as possible. The trial could also lay the ground for a world-leading Australian industry in printable electronics.

The three-year, $12 million VICOSC solar cell project is 50 per cent funded by the Victorian Government through an Energy Technology Innovation Strategy Sustainable Energy Research and Development grant. VICOSC includes researchers from the CSIRO Future Manufacturing Flagship, the University of Melbourne and Monash University, along with industry partners Securency, BP Solar, Bluescope Steel and Merck.

Images provided by the Queensland Government Department of Employment, Economic Development and Innovation

Developing Superior Queensland Mangoes

Mangoes are one of Queensland's top five fruit crops. Queensland has a $100 million mango industry with significant potential for domestic and export market development. Breeding a new variety of mango can take up to twenty-five years. Queensland primary industries and fisheries scientists have participated in the development of new mango varieties.

In the late 1990s, Queensland Primary Industries and Fisheries, in partnership with a long-established mango grower, released two varieties now being marketed globally under the registered trademark Calypso by OneHarvest, a Queensland-based food company with global commercialisation rights. OneHarvest is negotiating production sites in the northern hemisphere to supply these mangoes all year round. A mango genomics initiative is developing biomarkers to investigate the genetics of mango flavour, skin colour and disease resistance, and the links between preferred fruit flavour and the flavour components in mango to improve the efficiency of breeding and allow faster development of new varieties. The genomics initiative is also investigating tree architecture genes and molecular markers to improve production and harvesting through the use of dwarf mango trees.

In the 2009-10 mango season, the farmgate value of Calypso mango will be approximately $17 million, with significant royalty returns to the variety owners. The Calypso-branded varieties represent a large improvement in international competitiveness thanks to their greatly increased productivity (mango yields on average for Calypso-branded varieties are greater than 30 tonnes per hectare, compared with an average of eight tonnes per hectare for the traditional Kensington Pride variety).

CHAPTER FOUR

Links and collaboration

Collaboration delivers important competitive advantages for businesses as they strive to innovate quickly and efficiently to compete in global markets. Many innovating businesses reduce costs and manage risks by collaborating with suppliers, customers, universities or publicly funded research organisations (PFROs). This enables businesses to tap into ideas and expertise available in national and global networks to resolve challenges, create new products and services, and become more competitive and profitable.

Recognising the significant benefits of collaboration and knowledge transfer between the public and private sectors, the Australian Government aims to strengthen links and collaborations within the national innovation system and encourage universities and PFROs to provide a solid national platform for successful innovation.

Australia produces 2 per cent of world research, so the performance of our innovation system depends on mechanisms to extract, filter, and apply the other 98 per cent. Maintaining and developing international collaborations provides significant benefit for Australian researchers and businesses by enabling access to new knowledge and developments and leveraging domestic investments in research and infrastructure.

Substantial evidence exists showing that countries and regions with strong innovation performance share common characteristics, including strong collaboration and networking between industry and researchers and a high level of global integration in research and innovation activities.

In *Powering Ideas*, the Australian Government set out its priorities and targets for links and collaboration as follows:

Priority 5: The innovation system encourages a culture of collaboration within the research sector and between researchers and industry.

Target: The Australian Government's ambition is to double the level of collaboration between Australian businesses, universities and publicly-funded research agencies over the next the next decade.

Priority 6: Australian researchers and businesses are involved in more international collaborations on research and development.

Target: The Australian Government has adopted the long-term aim of increasing international collaboration in research by Australian universities.

This chapter highlights Australia's performance in knowledge exchange and global integration compared with other OECD countries. It outlines achievements and actions addressing these priorities and targets undertaken by the Commonwealth and state and territory governments to enhance Australia's performance in networking and collaboration, and provides case studies to illustrate the importance of collaboration between businesses and researchers.

Highlights of baseline performance

Knowledge exchange

Knowledge exchange depends largely on links and connections between organisations and individuals. This is particularly the case for tacit knowledge held in the minds of people or in the routines of organisations. Direct interaction is required to gain access to this knowledge; however, there is little data available to measure this kind of informal knowledge exchange. Existing data collected from various sources is primarily focused on formal knowledge exchanges, such as collaboration and funding flows between the public and private sectors, and research commercialisation activities.

Table 9 suggests that Australia has a mixed performance in formal knowledge exchange. Australia sits in the top half of OECD countries for business-financed R&D performed by universities and PFROs, and patents owned by universities and PFROs. Australia ranks among the mid-range of OECD countries for SMEs collaborating in innovation with higher education institutions and government institutions. For large firms, Australia ranked towards the bottom of the group of OECD countries in innovation collaboration with higher education institutions and government institutions. Australia's smallest distance from the top five OECD countries is 23.7 per cent for the proportion of government expenditure on research and development (GOVERD) financed by business; the largest is the 79.6 per cent by which large firms in Australia lag on collaborating in innovation with government institutions.

Table 9: Australia's performance in knowledge exchange against other OECD countries

Indicators	Latest Figure	Reference Year	OECD Ranking	Gap from the Top Five OECD Performers	Data Source
Proportion of innovation-active businesses collaborating with universities*	**1.6%**	**2006-07**	**- [a]**	**-**	**(1)**
Proportion of innovation-active businesses collaborating with publicly-funded research agencies*	**7.2%**	**2006-07**	**-**	**-**	**(1)**
Proportion of SMEs collaborating in innovation with higher education institutions	3.1%	2004-06 [b]	13th [c]	62.6%	(2)
Proportion of SMEs collaborating in innovation with government institutions	2.9%	2004-06 [b]	9th [d]	49.2%	(2)
Proportion of large firms collaborating in innovation with higher education institutions	10.0%	2004-06 [b]	20th [c]	75.8%	(2)
Proportion of large firms collaborating in innovation with government institutions	5.8%	2004-06 [b]	22nd [d]	79.6%	(2)
Proportion of Australian-authored papers co-authored by researchers from more than one Australian research institution	31%	2001-05	-	-	(3)
Gross income from Licences, Options and Assignments by publicly funded research organisations and universities	$214m	2007	-	-	(4)
Gross income from contracted research by publicly funded research organisations and universities	$1.23b	2007	-	-	(4)
Start-up companies in which publicly funded research organisations and universities have an equity holding	205	2007	-	-	(4)
Share of patents owned by universities and government	7.0%	2003-05	8th [e]	27.1%	(5)
Proportion of HERD financed by business	6.7%	2006	12th	56.8%	(6)
Proportion of GOVERD financed by business	12.1%	2006	7th [f]	23.7%	(6)

Sources: (1) ABS (2008), *Innovation in Australian Business 2006-07*, cat. no. 8158.0. (2) OECD, *Science, Technology and Industry Scoreboard 2009*. (3) Australian Research Council (2009) ARC–supported research: the impact of journal publication output 2001–2005. (4) DIISR (2009), *National Survey of Research Commercialisation 2005-07*. (5) OECD, *Compendium of Patent Statistics 2008*. (6) OECD, Main Science and Technology Indicators database, 2009/2.
Notes: Indicators with * and in the coloured rows of the table are the primary indicators applied to measure and monitor progress against the Australian Government's innovation targets. (a) -: Not available. (b) Figures for Australia are for 2006-07. (c) Only 23 OECD countries are compared including two accession countries. (d) Only 22 OECD countries are compared including two accession countries. (e) Excludes Greece, Iceland, Poland, Portugal and the Slovak Republic. (f) Excludes Switzerland.

In the Australian Bureau of Statistics innovation survey, collaboration is defined as "active participation in joint innovation projects with other organisations", but excludes the pure contracting out of work. Collaboration can involve the joint development of new products, processes or other innovations with customers, suppliers, other enterprises or PFROs.

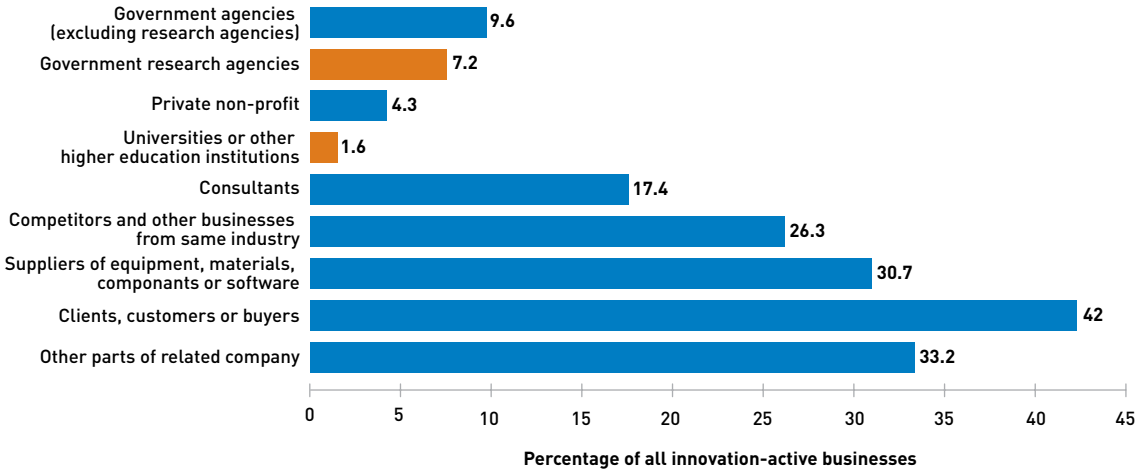
In 2006-07, 3.1 per cent of Australia's SMEs collaborated with higher education institutions in innovation (ranked thirteenth out of twenty-three OECD countries) while 2.9 per cent of SMEs collaborated with government institutions (ranked ninth out of twenty-one OECD countries). The performance of Australia's large firms, compared to those in other OECD countries, was less impressive, with 10 per cent collaborating on innovation with higher education institutions (ranked twentieth out of twenty-three OECD countries) and 5.8 per cent with government institutions (last out of twenty-two OECD countries).

The proportion of innovation-active businesses collaborating with universities and PFROs indicates the level of collaboration in innovation between businesses and researchers from the public sector. This indicator is applied to measure and monitor progress against the Australian Government's target to double the level of collaboration between Australian businesses, universities and PFRAs over the next decade. As shown in Chart 16, in 2006-07, 1.6 per cent of innovation-active businesses collaborated with universities, while 7.2 per cent of such businesses collaborated with PFRAs in Australia.

Analysis of co-authorship of research papers shows that collaboration on the part of Australian research institutions has increased. Between the periods 1996-2000 and 2001-2005 the percentage of Australian-authored papers that were co-authored by researchers from more than one Australian research institution rose from 27 per cent to 31 per cent.[48]

48 Australian Research Council (2009) *ARC–supported research: the impact of journal publication output 2001–2005* (Table A2 p.164) and Australian Research Council (2004) *ARC–supported research: the impact of journal publication output 1996–2000* (Table A3 p.164)

Chart 16: Innovation-active businesses collaborating in Australia – by type of organisation collaborated with, 2006-07



Source: ABS (2008), *Innovation in Australian Business, 2006-07, cat. no. 8158.0*

The National Survey of Research Commercialisation, conducted by the Department of Innovation, Industry, Science and Research (DIISR), collects data on the commercialisation activities of PFROs in Australia as well as universities and Cooperative Research Centres (CRC). In 2007, PFROs, universities and CRCs reported gross incomes totalling $214 million from licences, options and assignments, and $1.23 billion from contracts and consultancies with end-users. By 2007, the PFROs recorded having an equity holding in 205 start up companies.

The share of public institutions (government laboratories and universities) in the ownership of patents reflects both the strength of their technological research and the legal framework. Universities and government laboratories owned 7 per cent of all Australian patents filed under the Patent Cooperation Treaty (PCT) between 2003 and 2005. On this measure, Australia ranked eighth out of twenty-five OECD countries.

The proportion of business-financed R&D in total R&D performed by universities and PFROs reveals some of the interaction and collaboration between these entities and businesses. In 2006, around 6.7 per cent of higher education expenditure on research and development (HERD) was financed by businesses in Australia, placing it twelfth in the OECD. An estimated 12.1 per cent of government expenditure on research and development (GOVERD) was financed by business in Australia, ranking Australia seventh in the OECD.

Global integration

A wide range of metrics can be used to measure a national innovation system's global integration. Most scrutinised are the flows of research funding and highly-skilled people across borders and international research and innovation collaboration.

Table 10 summarises Australia's performance in global integration against other OECD countries. Australia has a relatively low rate of international collaboration on R&D and innovation by indicators of gross expenditure on research and development (GERD) financed abroad, co-authored scientific publications, patents with foreign co-inventors, total international technology payments and receipts, and firms involved in foreign cooperation on innovation. In contrast, Australia records one of the highest inflows of human capital from overseas among OECD countries, measured by the proportion of foreign-born people in the total population having a tertiary qualification (second highest in the OECD). Australia also has the sixth highest proportion of international students enrolled in advanced research programs in the OECD.

Table 10: Australia's performance in global integration against other OECD countries

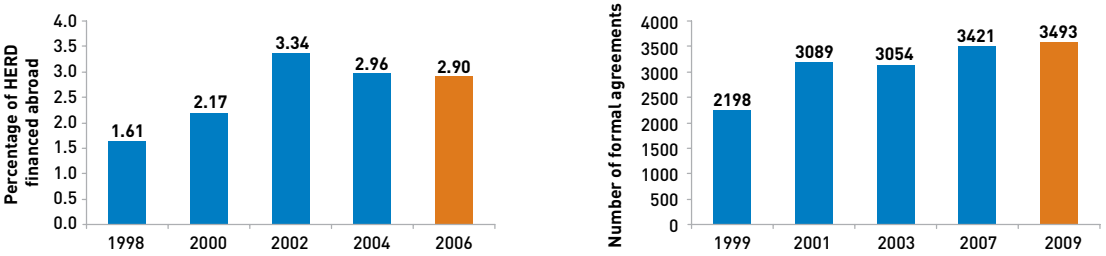
Indicators	Latest Figure	Reference Year	OECD Ranking	Gap from the Top Five OECD Performers	Data Source
Proportion of GERD financed abroad	2.4%	2006	25th (a)	85.6%	(1)
Share of HERD financed by abroad*	2.9%	2006	- (b)	-	(2)
Number of formal agreements on academic/research collaboration between Australian universities and overseas institutions*	3,493	2009	-	-	(3)
Proportion of Australian S&E publications co-authored with foreigners	38.9%	2003	25th (c)	34.1%	(4)
R&D expenditure of foreign affiliates as a % of R&D expenditure of the enterprise	36.6%	2006	7th (d)	41.7%	(1)
Proportion of firms with foreign cooperation on innovation	1.0%	2002-04	23rd (e)	94.4%	(5)
Proportion of patents with foreign co-inventers	13.3%	2005	25th	71.5%	(6)
Technology balance of payments – sum of receipts and payments as a % of GDP	0.92%	2007	19th (f)	90.0%	(1)
Net gains of highly-skilled persons through migration	10,006	2007-08	-	-	(7)
Proportion of foreign-born in the total employed population with a tertiary qualification	29.6%	2000	2nd (g)	1.5%	(8)
Proportion of international students enrolled in advanced research programs	20.8%	2007	6th (h)	34.3%	(9)

Sources: (1) OECD, Main Science and Technology Indicators database, 2009/2. (2) ABS, *Research and Experimental Development, Higher Education Organisations, 2006*, cat. no. 8111.0. (3) Universities Australia, *International Links of Australian Universities*, May 2009. (4) National Science Board, *Science and Engineering Indicators 2006*. (5) OECD, Science, *Technology and Industry Scoreboard 2007*. (6) OECD, *OECD in Figures 2008*. (7) Department of Immigration and Citizenship (DIAC), Special data request provided in February 2009. (8) OECD, Immigrants database. (9) OECD, *Education at a Glance 2009:OECD indicators*.
Notes: Indicators with * and in the coloured rows of the table are the primary indicators applied to measure and monitor progress against the Australian Government's innovation targets. (a) Excludes the USA. (b) -: Not available. (c) Excludes Luxembourg. (d) Excludes Denmark, Iceland, Korea, Luxembourg, Mexico, New Zealand and Switzerland. Australia's figure is derived from the ABS business R&D data for 2006-07. (e) Excludes Iceland, Ireland, Mexico, Switzerland, Turkey, UK and USA. (f) Excludes Iceland, Netherlands and Turkey. (g) Excludes Japan, Turkey and USA. (h) Excludes France, Germany, Greece, Ireland, Italy, Korea, Luxembourg, Mexico, Netherlands, Poland, Portugal and Turkey.

The proportion of GERD financed overseas gives a gauge of international collaboration in R&D activities. Funding from abroad represented around 2.4 per cent of GERD in 2006, ranking Australia twenty-fifth out of twenty-nine OECD countries.

The share of university R&D financed from abroad and the number of formal agreements on academic and research collaboration between Australian universities and overseas institutions are used as primary indicators of progress against the Government's target of increasing international collaboration in research by Australian universities. As shown in Chart 17, around 2.9 per cent of HERD was financed abroad in 2006, down from a peak level of 3.3 per cent in 2002. There were 3,493 formal agreements on academic research collaboration between Australian universities and overseas institutions in 2009.

Chart 17: International research collaboration by Australian universities, 1998-2009



Sources: ABS (2008), *Research and Experimental Development, Higher Education Organisations, 2006*, cat. no. 8111.0; and Universities Australia, *International Links of Australian Universities*, May 2009
Note: Data on the number of formal agreements for 2005 is not available.

International co-authorship is regarded as an important indicator for international science cooperation by a country's research community. Approximately 38.9 per cent of Australian science and engineering publications were co-authored with at least one foreigner in 2003. This was relatively low by OECD standards, ranking twenty-fifth out of twenty-nine OECD countries.

The presence of research-performing foreign affiliates enables the host country to benefit from their technological and organisational capabilities. The share of foreign affiliates in R&D is commonly used to measure the internationalisation of R&D in a country. R&D expenditure by foreign affiliates as a percentage of R&D expenditure by all businesses in Australia was 36.6 per cent in 2006 (ranked seventh out of twenty-three OECD countries).

The proportion of Australian businesses collaborating with foreign organisations on innovation is low – just 1 per cent of all firms – and places us second last, equal to Japan, out of twenty-four OECD countries.

International co-invention of patents is a proxy for formal R&D cooperation and knowledge exchange between inventors located in different countries. In 2005, 13.3 per cent of patents invented in Australia had at least one foreign inventor involved. This is relatively low, ranked twenty-fifth among OECD countries.

The technology balance of payments measures international technology transfers such as licence fees, patents, purchases and royalties paid, know-how, research and technical assistance. Unlike R&D expenditures, these are payments for production-ready technologies. Measured by their share of GDP, Australia (0.92 per cent) was ranked nineteenth out of twenty-seven OECD countries in total technology payments and receipts.

The flow of people with knowledge and skills across a country's borders also provides an indicator of its international engagement. Through migration, Australia received a net gain of 10,006 highly-skilled workers in 2007-08, comprising 6,933 professionals and 3,073 associated professionals.

In 2000, 29.6 per cent of the total employed population with tertiary qualifications in Australia was born overseas, placing Australia second only to Luxembourg in the OECD. International students accounted for 20.8 per cent of Australian enrolments in advanced research programs in 2007, with Australia ranking sixth among eighteen OECD countries.

Enhancing collaboration within the national innovation system

Achievements and actions by the Australian Government

Supporting collaboration between the public and private sectors

Cooperative Research Centres Program

The objective of the Cooperative Research Centres (CRC) Program is to deliver significant economic, social and environmental benefits to Australia by supporting end-user-driven research partnerships between publicly-funded researchers and end users to address clearly articulated, major challenges that require medium- to long term collaborative research efforts.

Since the inception of the CRC Program in 1990, 185 CRCs have been funded or approved for funding. Over that time, the Australian Government has committed more than $3.3 billion to CRCs, while CRC participants have committed a further $10.8 billion in cash and in kind. Actual participant contributions are significantly higher than contracted contributions - for example, data up to 2007 08 shows actual participant contributions were $1 billion over their contracted amounts.

Changes to the CRC Program since the introduction of new program guidelines in November 2008 include:

- requiring all CRCs to have SME engagement strategies to build their innovation and R&D capacity
- encouraging CRCs to engage globally, particularly through co-investment arrangements
- expanding research eligibility to all research disciplines
- encouraging CRCs in all sectors of Australian industry, including the services sector
- increasing flexibility and streamlining processes to make it easier for participants to move in and out of CRCs
- implementing annual selection rounds to respond to new and emerging priorities.

Ten CRCs received a total of $243 million in the eleventh CRC selection round. Round 11 contracts commenced early in 2010. Seven CRCs received a total funding of $130 million in the twelfth round. Contracts for successful applicants in Round 12 are expected to commence in July 2010. The Government has also committed an additional $15 million over three years from July 2010 for the Bushfire CRC to respond to research issues arising from the 2009 Victorian bushfires.

The thirteenth CRC selection round opened in December 2009. While applications are encouraged from all industry and community sectors and research disciplines, applications in the priority areas of manufacturing innovation and social innovation are particularly encouraged. Applications for Round 13 close on 2 July 2010.

Collaborative Research Networks Program

The Collaborative Research Networks (CRN) Program, announced in the 2009-10 Budget, will provide $52 million from 2011 to assist smaller and regional universities in adapting to a research system driven more strongly by performance outcomes. It will complement other reforms to the research block grants system, which include a greater emphasis on collaboration by universities with the business and non-government research sectors.

CRN will encourage smaller and regional universities to form collaborative partnerships with larger, more research-intensive universities. These partnerships will support areas of national importance, and will be built around existing and developing research strengths for the universities involved. CRN will, in part, ensure that local communities, businesses and industries across Australia, and especially in regional areas, continue to have access to world-class researchers and research facilities through collaborative networks. Smaller and regional universities often have strong links with local businesses and communities, and much of their research is addressed towards regional needs and priorities. CRN will help them to increase their collaboration with local business and industry as well as other universities.

The Department of Innovation, Industry, Science and Research held preliminary consultations with universities on the scope of CRN as part of the discussions on the interim agreements settled for 2010 as a prelude to mission-based compacts. The eligibility criteria for CRN will be developed through further consultations with universities during the first part of 2010. A discussion paper to guide the consultation process was released in February 2010 and funding will be made available to successful universities from 1 January 2011.

Joint Research Engagement

The Joint Research Engagement (JRE) Scheme, which replaced the Institutional Grants Scheme (IGS) in January 2010, is designed to encourage universities to diversify their sources of research income and increase their collaboration with the business and non government research sectors.

Under JRE, the IGS funding formula has been revised to remove competitive research grant income from calculations used to allocate this research block grant, thereby rewarding universities which diversify their sources of research income. JRE gives greater emphasis to end-user research by encouraging and supporting links between universities, industry and end-users, beyond those specifically supported by competitive grants.

This initiative is a companion reform to Sustainable Research Excellence in Universities and the Collaborative Research Networks Program. Together, they form a comprehensive suite of support that will enable universities to build capacity to successfully undertake basic and industry-driven research.

ARC Linkage Projects

The Linkage Projects Scheme supports research collaboration between higher education organisations and other organisations (including industry, government and community partners in Australia and internationally). The scheme aims to apply advanced knowledge to problems and bring economic and social benefits to Australia.

Two selection rounds are conducted each year. In the two selection rounds for funding commencing in 2009, the 457 successful projects involved 1,013 partner organisations, which pledged cash and in-kind contributions of $256.9 million to the projects ($1.79 for every $1 contributed by the ARC). In the first selection round for funding commencing in 2010, partner organisations involved with the 211 successful proposals pledged cash and in-kind contributions of $121.4 million. Proposals for Round 2 closed on 18 November 2009.

Australian Postgraduate Awards (Industry) (APAIs) are awarded under the Linkage Projects scheme to support postgraduate research students studying towards masters and PhD degrees. They help produce a highly skilled and flexible pool of researchers capable of moving between the higher education sector and other sectors to meet the needs of the broader Australian innovation system.

In the two Linkage Projects selection rounds for funding commencing in 2009, 362 APAIs were awarded. In the first selection round for funding

commencing in 2010, 145 APAIs were awarded. Australian Postdoctoral Fellowships (Industry) and Linkage Industry Fellowships are also offered under the scheme.

Researchers in Business

The Researchers in Business (RiB) component of Enterprise Connect supports the placement of researchers from universities or PFRAs in firms aiming to develop new ideas with commercial potential. The objectives of RiB are to help break down the cultural divide between business and the research sector, to stimulate the dissemination of expertise from research organisations to industry, and to accelerate the adoption of new ideas and technologies by Australian SMEs.

RiB provides funding for up to 50 per cent of salary costs, to a maximum of $50,000 for each placement between two and twelve months. The program assists businesses to identify researchers and organise RiB projects through its partner linkage providers. The two linkage providers – the Australian Institute for Commercialisation and CSIRO – provide assistance to businesses free of charge. As of 31 December 2009, a total of nineteen RiB projects had been approved to a value of $793,340.

Achievements and actions by state and territory governments

Victoria

Victoria's Science Agenda Investment Fund

Victoria's Science Agenda Investment Fund provides competitive grants worth $41 million to business and research organisations for collaborative projects that develop and use Victoria's science and technology capabilities to make Victoria more productive, sustainable and healthy. It will support market-focused projects that deliver economic, environmental and health benefits. Grants of between $300,000 and $3 million will be provided for eligible projects. Eighteen projects have been announced so far, with a further seven projects to be announced later in 2010.

New South Wales

TechVouchers

The NSW Technology Vouchers Program (TechVouchers) drives innovation in industry through long-term research partnerships between SMEs and public sector research organisations located in New South Wales. To be eligible, companies must be NSW-based, in operation for at least one year, have less than 200 employees, and collaborate with a NSW university, TAFE or a PFRO.

The objective of the program is to encourage companies to use PFROs to solve specific problems, and to enter into collaborative research partnerships that draw on the capabilities of the company and research partner. TechVouchers is being implemented by the NSW Government through Industry and Investment NSW, in conjunction with InnovationXchange Limited.

South Australia

Medical Devices Partnering Program

The Medical Devices Partnering Program (MDPP) is a collaboration between South Australian researchers, end-users and industry to develop cutting-edge medical devices and assistive technologies in an effort to make them into market-ready solutions. The MDPP supports the development of products with an identified clinical need, sound technical base and a viable market opportunity.

Supported with seed funding from the South Australian Premier's Science and Research Council, the MDPP brings together a network of stakeholders in the medical device development process, facilitates new, targeted partnerships between research organisations and companies, and provides practical assistance in taking ideas closer to the market.

In a relatively short period of time, this unique collaboration of researchers, industry, clinical end-users and government has engaged more than fifty companies into the program, resulting in thirty new industry-focused projects, with benefits to researchers including increased collaboration and opportunities for research funding. Examples of MDPP contributions to the development of specific products include a new device for use in surgery and a novel computer-based appointment reminder system for dementia sufferers.

The MANA Calendar – computer-based appointment reminder

Increasing international collaboration on R&D

Achievements and actions by the Australian Government

Supporting international collaboration on research

International Science Linkages Program and the Australia-India Strategic Research Fund

The Australian Government supports international collaboration through the International Science Linkages (ISL) Program and the Australia-India Strategic Research Fund (AISRF). These programs provide an important platform for international collaborative research at government-to-government and researcher-to-researcher level.

In 2008 and 2009, ISL supported 576 international collaborative activities, including:

- research projects with China, France, the USA, Singapore, Brazil, Germany, the UK and Japan
- strategic policy activities, including international workshops and symposia and research exchanges
- fellowships, international research conferences, and science and technology missions under the ISL Academies Program.

During the same period, the AISRF supported forty-three high-quality collaborative research projects and five bilateral workshops in key areas of research. Of $68.8 million awarded under both of these programs during this time, three-fifths has been provided to tertiary education institutions.

In 2008, ISL added two new components to broaden and deepen Australia's international science and technology engagement with key countries in strategic areas of research:

- a targeted collaborative fund with Europe, an important region in which Australia stands to benefit enormously by engaging with global leaders in research
- investment in humanities and social sciences research which is essential to meeting some of the great challenges facing the world today and underpins Australia's contribution to the global research effort.

In November 2009, the Australian and Indian Prime Ministers agreed to extend the AISRF and increase its level of funding. The Australian Government will commit $10 million per annum for five years commencing 2009-10, with the Indian Government to provide matching funding. ISL is scheduled to cease operations on 30 June 2011.

Visiting Researcher Program

Visiting Researcher Program

The Visiting Researcher Program is jointly funded by Austrade and Australian Education International and allows researchers from across Australia to visit research universities in Europe and develop collaborative ties between the two continents. The focus for the program in 2009 was clean technology and all topics related to the environment as a way of showcasing solutions and innovations in the run-up to the United Nations Climate Change Conference in December 2009.

Outcomes to date have included agreement on the exchange of senior Australian and European researchers and PhD students, including the provision of scholarships, and several joint projects on combustion technology. Other collaborations are being developed and should be announced in 2010.

Internationalising research programs

Changes to research programs for international applicants

The Australian Government's broader approach to supporting international science collaboration involves internationalising research programs. For example, changes have been made to the ARC's Discovery Projects, Linkage Projects and other NCGP schemes to enhance international collaboration.

In the Discovery Projects rules for funding commencing in 2010, a new internationalisation objective has been added, overseas-based partner investigators will be eligible for funding for travel to Australia, and International Collaboration Awards have been introduced to enable chief investigators, fellows and overseas-based partner investigators to travel for the purpose of collaborative research. Among the 925 ARC Discovery Projects announced on 26 October 2009, 104 received one or more International Collaboration Awards.

For Linkage Projects, rules for funding commencing in 2009 relaxed the citizenship and residency requirements for APAI students, while overseas higher education organisations were made eligible to participate as partner organisations. International collaboration is a priority for all ARC fellowship schemes and all fellowships are open to non-Australian citizens.

Changes have also been made to other major Government programs to support international collaboration. For example, CSIRO's Flagship Collaboration Fund is now open to applications from overseas research organisations, and Cooperative Research Centres are now encouraged to engage globally and co-invest with international partners under new guidelines released in 2008 for the re-invigorated CRC Program.

Achievements and actions by state and territory governments

Victoria

Victoria-California stem cell alliance

This three-year program to support international research was established in June 2008 between the Victorian Government and California Institute for Regenerative Medicine (CIRM). It aims to accelerate treatment of disease by facilitating strategic international collaborative projects between stem cell scientists.

Four joint projects worth US$22.3 million have already been funded by the alliance, with US$3.7 million from the Victorian Government and US$18.6 million from CIRM. Each project supports early translational research that will take stem cell science and technologies from the laboratory to the development of safe clinical stem cell therapies for patients.

In October 2009, a further $2 million was announced for Victorian stem cell researchers as part of the alliance program. This new funding will focus on research into stem cell transplantation immunology, which is aimed at ensuring human immune tolerance of stem-cell-derived cell and tissue grafts, such as skin, bone and organ tissue.

The current projects include work on neural stem cells as therapies for Parkinson's and Alzheimer's diseases, and on ensuring quality control of stem cells to be used in stem-cell-based therapies.

Western Australia

International Centre for Radio Astronomy Research

In 2008, the Western Australian Government committed $20 million to help establish the International Centre for Radio Astronomy Research (ICRAR), a joint venture between Curtin University of Technology and the University of Western Australia. ICRAR is a collaborative centre that is international in scope and is making pivotal science and engineering contributions to the realisation of the Square Kilometre Array (SKA) – a research infrastructure project involving twenty nations collaborating on a large-scale, next-generation radio telescope with 10,000 times the survey speed of current instruments.

ICRAR is committed to building national and international industry partnerships and research collaborations, and is providing opportunities to develop new skills and build industrial capabilities in Western Australia.

In July 2009, ICRAR signed a memorandum of understanding (MOU) with the UK based headquarters of the SKA project, the SKA Program Development Office. Under the MOU, ICRAR will be the major partner in developing conceptual designs for the high performance computing and data management systems of the SKA.

In September 2009, ICRAR signed an MOU with IBM to research and develop IT systems for the transfer, management, processing and storage of the vast amount of data that will be generated by the SKA and the Australian SKA Pathfinder telescope. This partnership merges science with industry to support the Australia-New Zealand bid to host the $2.5 billion SKA project.

Northern Territory

Technical advances in hatchery production of barramundi

The Northern Territory Government's aquaculture program has as its vision "A sustainable aquaculture industry that provides significant economic and social benefits for the people of the Northern Territory." Through its Darwin Aquaculture Centre (DAC), the NT Government has been pursuing development objectives which include: assisting industry in developing effective production systems for appropriate tropical species; working with industry to ensure high-quality environmental performance; and operating an aquatic animal health service to safeguard the health status of the industry.

The NT Government has invested continuously in the development of barramundi aquaculture since 1988. The R&D program initially focused on adapting techniques developed for barramundi culture in South-east Asia to Northern Territory environmental conditions. The Government's involvement and commitment to R&D acted at the time as a basis from which to attract private sector investment.

Over the years, the Territory's barramundi aquaculture program has adopted a strategy of continuous improvement with considerable effort and resources being devoted to improve production efficiencies in the hatchery. A series of very valuable cooperative and collaborative links between the DAC and a range of public and private institutions between 2000 and 2008 resulted in a quantum leap in hatchery production of juvenile barramundi. Links were established with organisations as diverse as the University of North Carolina in the USA, the Institut Français de Recherche pour l'Exploitation de la Mer in France, the University of Sydney, the University of Queensland, and private-sector finfish farms, hatcheries and feed manufacturers in Australia, France, Greece, Mexico and Japan.

Improvements were made in all areas of the production system, ranging from system design, water quality treatment, live food production, diet formulation and method of delivery, improvements in fish husbandry and better animal health management. The end result of this collaboration has been the development of semi-automatic hatchery production system for barramundi, which has increased production capacity tenfold, improved reliability, requires less labour and produces fish that grow faster and are healthier.

Counting juvenile barramundi in the Darwin Aquaculture Centre's nursery

Some of the juvenile barramundi produced at the Darwin Aquaculture Centre. More than 12 million fish have been produced since 2001

Feeding the juvenile barramundi in the Darwin Aquaculture Centre's nursery
Images provided by the Northern Territory Government

CASE STUDIES: BUSINESSES

OneSteel: Polymer injection technology

Australian steelmaker OneSteel, working in close collaboration with a team led by Professor Veena Sahajwalla of the University of New South Wales (UNSW) Centre for Sustainable Materials Research and Technology, has developed a technology that can improve production and reduce costs at its electric arc furnace facilities in Sydney and Melbourne.

The process replaces some of the coke used in electric arc furnace steelmaking with polymers, including recycled rubber and plastic. An advantage of the technology is a reduction in both the volume of carbon coke injected and the electricity consumed per tonne of steel produced. Positive flow-on effects include a reduction in electricity consumed by the furnaces, an upstream reduction in greenhouse emissions from coal-fired power stations, and the removal of used car tyres from the waste stream.

OneSteel employs the technology commercially in its Laverton and Sydney steel mills, where it has the potential to consume over 250,000 tyres a year that would otherwise go to landfill. OneSteel has the exclusive right to market this technology worldwide through a business arrangement with UNSW's commercial arm, NewSouth Innovations Pty Ltd.

Textor Technologies

Textor Technologies manufactures products that have a fluid-fibre interface. The ability of Textor Technologies' products to control the behaviour of liquids has applications in medicine (post-operative and orthopaedics), personal hygiene (babycare, femcare, and incontinence products), filtration and food packaging.

The company continues its investment in technologies with the assistance of the Australian Government's TCF Post-2005 (SIP) Scheme. This is complemented by investment in R&D, both internally and in partnership with some of Australia's leading research institutions, including CSIRO, Deakin University and RMIT University. Textor Technologies has also recently signed onto the Researchers in Business program offered by Enterprise Connect. This will see a CSIRO researcher working on site with the company for twelve months to help develop second-generation fluid-fibre materials.

Textor Technologies now exports around 20 per cent of its turnover to countries such as Singapore, Vietnam and India and is looking to the Asia-Pacific market to increase this figure with a number of innovative new products.

Simavita

Melbourne-based Simavita (formally Fred Bergman Healthcare) specialises in products that improve the quality and cost of clinical and community care. Its first product, the SIMsystem, is for the assessment and management of urinary continence for residential aged-care facilities.

In developing the SIMsystem, Simavita was keen to collaborate with the research sector to access specific research capabilities it did not possess. With the assistance of the Australian Institute for Commercialisation's TechFast program, the company identified R&D partners and formalised effective commercial relationships with CRC Smartprint and Nanotechnology Victoria. It established knowledge transfer based collaborations with these organisations to successfully develop the product.

The SIMsystem was launched onto the Australian market in August 2009. Since then, it has been rapidly gaining support from the residential aged-care sector, the community and health professionals everywhere. There is significant interest from global markets, with a European licensee already established. The SIMsystem was recently one of three finalists in the prestigious Kerrin Rennie Award for Excellence in Medical Technology.

CASE STUDIES: UNIVERSITIES

Technology that converts fly ash into lightweight building product

Fly ash is an unavoidable by-product of burning coal to produce electricity. Around 800 million tonnes of the fine white powdery residue is generated globally each year to be dumped in disused mine shafts, residue ponds and other sites.

Obada Kayali and Karl Shaw of the University of New South Wales' Australian Defence Force Academy have pioneered a way to lock up fly ash by producing bricks and building aggregate that are stronger and lighter than comparable products. Fly ash bricks generate fewer emissions than standard clay bricks during manufacture because they need less kiln time. The adoption of fly ash products by the construction sector would confer many benefits, including lower construction costs and less greenhouse emissions due to lighter structures, shallower foundations and cheaper transportation costs.

In 2008, Vecor Building Systems signed a major business deal with NewSouth Innovations to commercialise fly ash technology globally. Vecor is working with the Hebi Municipal Government in China to build the world's first brick and tile factory using fly ash technology. To be built next to a coal-fired power station, it will have the capacity to produce 500 million bricks, fifty million pavers, and twenty-five million square metres of ceramic products annually.

CASE STUDIES: PUBLICLY FUNDED RESEARCH ORGANISATIONS

CSIRO's National and International Collaboration

CSIRO has extensive collaborative relationships and arrangements with universities and other research partners, both in Australia and overseas.

- During 2008-09, CSIRO staff and their colleagues in Australian universities co-supervised nearly 700 postgraduate students.
- Many of CSIRO's staff are located on, or directly adjacent to, university campuses, providing the means for sharing infrastructure and improving opportunities for increased collaboration.
- In May 2009, the Australian Government announced $80 million of new funding for the National Centre for Square Kilometre Array (SKA) Science, which will provide supercomputing infrastructure for the Australian SKA Pathfinder (radio astronomy) project. This will be hosted by the Western Australian Interactive Virtual Environments Centre, a partnership between CSIRO and Western Australian universities.
- The 2009 Budget also included additional funding for the Australian Synchrotron, European Molecular Biology Laboratory and the Atlas of Living Australia, all research infrastructure partnerships between CSIRO and Australian universities, which also involve Australian researchers linking to their international colleagues.
- CSIRO manages the $114 million Flagship Collaboration Fund, which supports research in Australian universities and other PFROs that contribute to the ambitious goals of the National Research Flagships in areas of national priority – twenty collaborative research clusters have been established through the fund (involving thirty universities), along with over fifty collaborative projects, twenty-five visiting fellowships and 120 postgraduate scholarships.
- CSIRO is involved in over half of the existing Cooperative Research Centres – twenty-seven of fifty-one CRCs in 2009.
- CSIRO regularly forms long-term strategic alliances with partners. For example, during 2008-09, CSIRO developed new or significantly expanded strategic partnerships with BHP Billiton, Orica and AusAID.

CSIRO also works closely with industry to deliver benefits from its research. As one measure of this engagement, industry increased its investment in CSIRO research in 2008-09 to over $105 million. More than 160 companies are founded on CSIRO technologies and many others use CSIRO innovations in their business. CSIRO earns increasing revenue from intellectual property licensing and royalties. A recent highlight of the application of CSIRO science is the patented wireless technology used worldwide in hundreds of millions of mobile computing devices, which have earned very significant royalties for Australia.

In addition to its broad engagement with industry partners, CSIRO operates a number of specific programs to foster more effective innovation with industry partners, particularly SMEs:

- a dedicated Small and Medium Enterprise Engagement Centre to assist SMEs in navigating and engaging with CSIRO and the wider national innovation system, and to also connect them to CSIRO's partners in government and industry
- the Australian Growth Partnerships program, which provides investment funding to high-potential, technology-receptive SMEs to access CSIRO capability and intellectual property
- specific partnering programs in areas such as biotechnology and national security technologies
- support for researchers working with SMEs on eligible projects through Enterprise Connect.

CSIRO is actively engaged in international science collaboration and the global innovation system, and has been since its inception. Recent measures of collaboration show that:

- approximately 45 per cent of CSIRO's peer-reviewed scientific publications in 2008 were co-authored with partners and collaborators overseas
- CSIRO had seventy-three relationship agreements such as memoranda of understanding with partners in nineteen countries in 2008-09
- the organisation was engaged in approximately 700 collaborative activities in 2008-09 covered by contracts (not including publications) with partners in sixty-six countries.

Recent examples of CSIRO's international engagement include:

- collaborative research between CSIRO's Food Futures Flagship and Limagrain for advances in wheat breeding for value added traits
- involvement in major multilateral science efforts such as the Intergovernmental Panel on Climate Change, Square Kilometre Array (SKA), International Energy Agency and others
- technology transfer such as the successful licensing of CSIRO's UltraBattery technology to Furukawa Battery Company in Japan and East Penn Manufacturing Co in the USA
- contributing to Australia's international aid program, through the delivery of initiatives such as the Pacific Climate Change Science Program
- strategic relationships with major international science and innovation agencies such as Petronas Research in Malaysia, the Boeing Company and Bayer CropScience.

Rural Research and Development Corporations

There are fifteen rural research and development corporations (RDCs), covering virtually all of the agricultural industries. Six are statutory authorities and nine are industry-owned companies. The RDCs bring industry and researchers together to establish strategic directions for R&D and to fund projects that provide industry with the innovation and productivity tools to compete in global markets.

In 2008-09, the total expenditure by the RDCs on rural R&D was approximately $467 million. This figure includes around $207 million in Commonwealth funds and $244 million in levy contributions from industry. The RDCs invest according to industry R&D priorities, the Rural R&D Priorities and the Australian Government's National Research Priorities. The RDCs aim to disseminate the findings of their research through the most appropriate and effective means to ensure adoption in their respective industries.

In 2009, an ongoing evaluation of RDC investments showed that for every $1 invested, a return of $10.51 (in 2009 dollars) will be achieved over 25 years. This assessment was based on fifty-nine randomly selected project clusters or programs, representing $676 million in total investment. Of this total, $181 million came directly from the RDCs. This demonstrates their key role in fostering research collaborations and linkages between other research agencies.

The assessment also noted the significant environmental and social benefits flowing from the fifty-nine research projects, including improved sustainability of production, reduced pollution (including greenhouse gases) and building the capacity of regional communities.

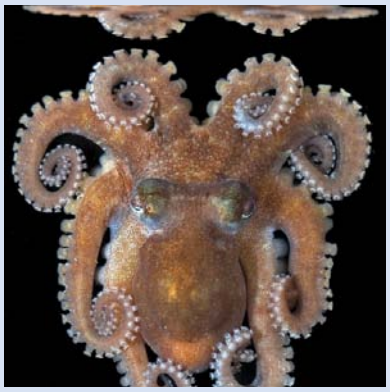
Innovative collaboration in computational strategic planning

In support of a project aimed at providing the Australian Defence Force with future field vehicle capabilities, the Defence Science and Technology Organisation (DSTO) has forged a strong collaboration with the University of New South Wales Defence and Security Applications Research Centre (DSARC) led by Professor Hussein Abbass. The partnership's prime objective is to turn interdisciplinary research findings into sound and tangible advice for development of military field vehicle capability.

The collaboration has also generated new original research, in particular in the fields of computational strategic planning, multi-objective, spatio-temporal risk assessment, and evolutionary, agent-based scheduling and routing algorithms. The success of this research is reflected in a 2009 UNSW Golden Start Award, a joint 2010 ARC Discovery Project proposal, international research collaborations with Defence Research and Development Canada and the University of Birmingham in the UK, and over a dozen of scientific publications, nine of which were published in 2009.

In addition, a scheduling and routing software tool developed for the Defence project has been customised to meet the requirements of commercial transportation companies. Here, DSTO and DSARC have teamed up with an Australian SME to assess the software's commercial viability.

Baited Remote Underwater Video System
Images by Mike Cappo and AIMS



New octopus species
Image by Julian Finn

Lihou Reef Coral Sea
Image by AIMS, Long-term monitoring program

The Census of Coral Reefs

The Census of Coral Reefs (CReefs) is an international project. It is part of the global Census of Marine Life, a ten-year program initiated by the Alfred P. Sloan Foundation (USA) to understand the past, present and future states of marine biodiversity. The CReefs project aims to estimate how many species live on coral reefs, with current estimates ranging between one and nine million species. The Australian node of CReefs is led by the Australian Institute of Marine Science and supported by substantial funding from BHP Billiton in a partnership with the Great Barrier Reef Foundation.

Two rounds of CReefs field expeditions have now been completed. The final round of expeditions to Lizard Island and Heron Island on the Great Barrier Reef and Ningaloo Reef in Western Australia will be completed this year. Conservatively, more than 1,000 species thought to be new to science have been discovered so far.

The project has received a significant new support through co-investment with the Australian Biological Resources Study, more than doubling the original budget for taxonomic support. This funding was allocated to research projects using a peer-reviewed competitive process. A new collaboration with the Ocean Genome Legacy was established in 2009. It will enhance the capacity to produce genetic barcodes of the species sampled and represents a significant additional co-investment in CReefs. Six BHP Billiton employees joined CReefs field expeditions in 2009. As with the previous year, feedback from these employees was very positive and is helping the project team provide the best possible experience.

Throughout 2009, the project enjoyed substantial media coverage within Australia and globally. It also received an Outstanding Achievement Award for Collaboration Outside the Census at the recent all programs meeting of the CoML in Long Beach, California.

A rotavirus vaccine

Following the discovery of rotavirus as the cause of severe gastroenteritis by Professor Ruth Bishop, Dr Ian Holmes and colleagues at the Royal Children's Hospital in 1973, researchers from the Murdoch Children's Research Institute, the University of Melbourne and the Royal Children's Hospital have worked on the development of a rotavirus vaccine.

This oral vaccine is based on a unique human neonatal strain of rotavirus discovered in Melbourne. The goal is to protect infants against disease and death due to rotavirus infection from the day they are born. Each year more than 500,000 children under five years of age die due to rotavirus gastroenteritis – mostly in developing countries. In Australia more than 10,000 children are hospitalised annually due to rotavirus infection.

The vaccine is being developed with the support of the NHMRC, the New Zealand Health Research Council, the World Health Organisation and PATH, including a key collaboration with a developing country vaccine manufacturer, BioFarma Indonesia. A low-cost rotavirus vaccine that is safe and effective when delivered at birth has the potential to dramatically limit the current barriers to prevention of rotavirus disease and make a significant impact on child mortality worldwide.

CHAPTER FIVE

Public Sector Innovation

The public sector accounts for 28.6 per cent[49] of GDP in Australia. Increasing innovation in the government and community sectors to improve policy development and service delivery can generate considerable benefits to the Australian economy and society.

Public sector innovation involves the "creation and implementation of new processes, products, services, and methods of delivery which result in significant improvements in the efficiency, effectiveness or quality of outcomes".[50] The Australian public sector has produced a number of innovations of national significance. Some of these are organisational innovations, such as the Family Assistance Office and Centrelink, which have changed the means by which many government services are delivered to the public. Other innovations have been in the area of policy, such as the Higher Education Contribution Scheme, which created a new way to improve access to higher education while increasing the revenue base.

In *Powering Ideas*, the Australian Government has set public sector innovation as an innovation priority:

Priority 7: The public and community sectors work with others in the innovation system to improve policy development and service delivery.

This chapter describes some of the key issues associated with measuring public sector innovation. It then provides an update on the progress of the Commonwealth and state and territory governments in promoting innovation in the public sector. Finally, case studies are provided to illustrate how innovation takes place in public sector organisations.

Measurement of public sector innovation

Data measuring public sector innovation is scarce in every government jurisdiction because metrics are still underdeveloped. Improving metrics and data on public sector innovation is critical to measuring Australia's performance against other OECD countries and monitoring its progress against the innovation priority that the Government has set for public sector innovation.

The provision and availability of data and metrics relies on the cooperative work of all OECD countries to develop a framework for measuring public sector innovation. The framework can be used as a guideline for collecting and interpreting data on innovation in the public sector, just as the *Oslo Manual* is used for measuring innovation in business. The OECD has a taskforce on the measurement of innovation in the public sector (of which Australia is a member) which is currently looking at this measurement framework.

It has been well recognised that applying the *Oslo Manual* simply to public sector innovation is not appropriate. As the European PUBLIN research project on measuring innovation in the public sector suggested, "The direct application of any notions of 'private sector' technological or non-technological, product or process innovation to 'public sectors' does not address the key characteristics of any non-private, non market activities".[51]

In 2009, the Government commissioned a study on the metrics of the national innovation system.[52] This study identifies a number of issues for developing indicators and collecting data on public sector innovation. Survey questionnaires need to:

- be applicable to public organisations that vary substantially in size, the services they provide (such as government administration, health or education) and the level of government (local, state, or national)
- establish the statistical unit level for reporting – surveys of education, for instance, should decide whether to cover individual high schools, school boards, or education ministries

49 Australian Government (2009), *Budget Paper No.1, 2009-10*, Statement 10, Table 1, p.10-6.

50 Mulgan, G and Albury D (2003), *Innovation in the Public Sector*, Cabinet Office Strategy Unit, United Kingdom.

51 Koch, P and Hauknes, J (2005), *Innovation in the Public Sector*, PUBLIN report, NIFU STEP, Oslo.

52 Arundel, A and O'Brien, K (2009), *Innovation Metrics for Australia*, a report commissioned by the Department of Innovation, Industry, Science and Research.

- deliver results that are comparable across levels of government and different types of services.

Obtaining indicators for public sector innovation, as the study points out, requires surveys that are relevant to all types of public sector organisations and can be collected regularly over time. This will require a much better understanding of several components: the types of innovations that are relevant to the public sector, the enablers and barriers to public sector innovation, and how to measure the outcomes of public sector innovation.

The study recommends indicators for public sector innovation grouped into seven categories: enablers of innovation, types of innovation, innovation implementation methods, inputs to innovation, sources of ideas and knowledge for innovation, impacts of innovation, and barriers to innovation. The study also points out that regular reporting of innovations to a government agency by public sector organisations could be an alternative source of data.

Australia is following with interest, developments in the OECD and member countries. The project New Initiative to Measure Public Sector Innovation (NIMPSI) initiated by the Nordic countries involves a pilot survey of public sector innovation. Results from this pilot survey are expected to be available late in 2010 and contribute to the OECD public sector measurement taskforce. Australia will be examining options for measurement in light of this work.

Improving policy development and service delivery

Achievements and actions by the Australian Government

Public Sector Innovation Management Advisory Committee Project

Powering Ideas noted that the Australian Public Service Management Advisory Committee (MAC) was examining the recommendations relating to public sector innovation made in *Venturous Australia – Building Strength in Innovation*, and the capacity of the public sector to implement them.

The Department of Innovation, Industry, Science and Research led a steering committee and cross-agency project team investigating how to foster innovation in the public sector and reporting to the MAC Executive Committee. The steering committee comprised representatives of DIISR, the Australian Public Service Commission, the Australian Taxation Office, Centrelink, CSIRO, the Department of Finance and Deregulation, the Department of Health and Ageing, and the Department of Immigration and Citizenship. The project reported to the MAC executive committee in January 2010.

The project looked at the barriers to innovation in the public sector and the strategies that could be used to tackle those barriers. It also investigated tools and mechanisms that can be used by the public sector to increase or drive innovation. These tools include the use of competitions, ideas management systems, pilots and experimental spaces. The project considered issues such as the need to engage with risk and provided recommendations for how the public sector can foster an innovation culture that tackles barriers to innovation and shares and rewards innovative practices, including drawing on external expertise and ideas from citizens and stakeholders.

As at the end of February 2010, the report was being considered by the MAC executive committee.

Government 2.0 Taskforce

The idea of Government 2.0 is to use the new collaborative tools and approaches of Web 2.0 to achieve a more open, accountable, responsive and efficient government. The Government 2.0 Taskforce was announced by Ministers Tanner and Ludwig on 22 June 2009. The taskforce report was delivered on 22 December 2009.

The report, *Engage: Getting on with Government 2.0*, notes that Government 2.0 is central to the delivery of government reforms such as promoting innovation. The report observes that some Australian Government agencies are recognised as international leaders in their embrace of Government 2.0 approaches, including the Australian Bureau of Statistics and the National Library of Australia.

The report outlines that "Government 2.0 is a key means for renewing the public sector, offering new tools for public servants to engage and respond to the community, empower the enthusiastic, share ideas and further develop their expertise through networks of knowledge with fellow professionals and others. Together, public servants and interested communities can work to address complex policy and service delivery challenges."

The Government is expected to respond to the report shortly.

Better Practice Guide for Public Sector Innovation

In December 2009, the Australian National Audit Office released its Better Practice Guide, *Innovation in the Public Sector: Enabling Better Performance, Driving New Directions*. The purpose of the guide is two-fold. First, it provides a practical framework to assist public sector agencies in their management of innovation. Second, it aims to further promote an innovation culture within the public sector.

According to the guide, a number of factors influence the likelihood of public sector innovation. These include:

- an innovative culture, supported by leaders that encourages internally-generated innovation by employees at all levels and appropriately recognises and rewards these innovations
- a focused corporate strategy which embeds innovation
- Investment in skills, training and development opportunities
- active engagement with citizens, clients and stakeholders to gather external ideas and innovations
- mechanisms in place to assess and respond to new and emerging issues.

The *Better Practice Guide* provides a decision-support framework designed to assist agencies to manage innovation and to encourage an innovation culture across the Commonwealth public sector. Calculated risk-taking is a necessary feature of most types of innovation and this framework is intended to provide a risk-aware approach to innovation that counters risk-averse behaviour.

Reform of the Australian Government Administration

The Prime Minister announced the formation of an Advisory Group on the Reform of Australian Government Administration in September 2009. The Group was tasked with delivering a blueprint to equip the APS for the challenges and opportunities of the future. Following extensive public consultations, *Ahead of the Game: Blueprint for the Reform of Australian Government Administration* ('the Blueprint') was launched in March 2010.

The Blueprint identifies a broad range of mechanisms to enable APS agencies to capitalise on new thinking, new tools, and new trends. It challenges the APS to seek out more effective and efficient channels for delivering the services citizens require. It also recognises the importance of innovative and forward-looking advice in a rapidly changing policy landscape. Improving innovation, collaboration and strategic policy skills will be critical to meeting the future challenges facing the APS.

The Blueprint recommends the establishment of a strategic policy network to share best practice in strategic policy. It proposes senior leadership forums to foster and reward creativity and encourage greater collaboration across portfolio boundaries. A new Secretaries Board would be responsible for considering strategic policy issues, and commissioning projects on complex policy problems through cross-agency strategic policy project teams.

The Blueprint proposes reforms to build the workforce capability of the public sector including a more strategic approach to workforce planning and learning and development. This will help to meet recognised skills shortages, including in the area of high level policy and research.

Innovation is also supported through recommendations to encourage greater engagement with front-line staff, academia and the broader community in policy development. The Blueprint calls for more open government to better harness the views of the public and to make government information more readily available for analysis by third parties to contribute to the broader policy debate.

Australian Centre of Excellence for Local Government

The Australian Government has contributed funding for the Australian Centre of Excellence for Local Government to enhance professionalism and showcase innovation and best practice in the local government sector.

The successful consortium was announced in June 2009 and the centre was launched in December. The following programs will be rolled out in three phases over five years: research and policy foresight; innovation and best practice; governance and strategic leadership; organisation capacity building; rural, remote and indigenous Australia; and workforce development.

The centre will build R&D capacity to support policy formulation, drive innovation and help address the challenges facing local government. It will also build up a national network and framework within which local government organisations, government agencies, academic institutions, training bodies and other stakeholders can collaborate in areas of mutual interest. It will provide leadership in promoting informed debate on policy issues and a clearing house for the exchange of information and ideas. It will also provide input to inform policy Commonwealth and state government policy.

National Awards for Local Government

The Australian Government established the National Awards for Local Government in 1986 to recognise, reward and promote the innovative work of local governments across Australia and to encourage other councils to adopt these innovative practices. Winning projects are publicised, including on the website of the Department of Infrastructure, Transport, Regional Development and Local Government (www.infrastructure.gov.au/local/awards/). The 2009 awards were presented in June that year to twenty-one councils. The next awards will be presented in June 2010.

Excellence in e-Government Award

The Australian Government Department of Finance and Deregulation administers the Excellence in e-Government Awards through the Australian Government Information Management Office. The awards were introduced in 2006 to promote excellence in the use of ICT in Australia at all levels of government. The aim of the awards is to inspire government agencies to excel and innovate. They recognise the most outstanding initiatives in e-government that have been implemented in the previous two years, based on the positive impact they have had on the lives of Australian citizens and businesses.

The awards are assessed against three criteria: transformation of services to citizens government or business; innovative use of ICT in the delivery of government services; and accessible and usable ICT solutions. In 2010, the awards have been expanded to include categories across a number of ICT disciplines and to recognise outstanding achievement by an individual or team in any discipline. This year's categories are applications development, geospatial, project management, service delivery, and systems architecture.

An overall winner and the category winners are presented at the annual CeBIT Australia presentation dinner in May. In 2009, the Department of Immigration and Citizenship won the e-Award for its Visa Wizard and Citizenship Wizard project.

Achievements and actions by state and territory governments

Australian Capital Territory

Australian e-Government Technology Cluster

The Australian e-Government Technology Cluster is a Canberra-based initiative established in late 2009 by National ICT Australia (NICTA), the ACT Government, international corporations and smaller ICT companies. Its objective is to facilitate collaboration in developing technology that will enable governments to deliver better services, reduce costs and open up new opportunities for businesses.

The ACT Government has collaborated with the other partners to support the cluster for an initial three year period until 2012. It is also expected that the new initiative will position the Australian Capital Territory and Australia as the leading centre for e-government technology and innovation in the Asia-Pacific region.

CASE STUDIES: AUSTRALIAN GOVERNMENT

Digital education and innovation

Through the $2.2 billion Digital Education Revolution (DER), the Australian Government is working to harness the potential of innovation in ICT to transform the teaching and learning process in schools. Elements of the DER include the provision of computers, high-speed broadband, teacher professional development and digital learning tools and resources. In implementing the DER, the Government is working closely with key stakeholders, not only in the education sector but in the ICT, telecommunications, intellectual property, publishing and creative industries.

The National Digital Learning Resources Network (NDLRN) is an example of connections between the DER and Australia's innovation system. The NDLRN (formerly The Le@rning Federation) was established in 2001 to procure high-quality multimedia digital learning resources and has been supported by the Australian Government and school authorities. Since then, in response to changing and growing requirements in the schools sector, NDLRN has undergone significant changes, including the establishment of a system to directly deliver digital learning resources to users (Scootle), development of digital infrastructure that allows sharing and collaboration between teachers, development of sophisticated licensing and digital rights management systems, and endorsement of quality technical standards. Based on strong networks with the multimedia, IT and cultural industries, NDLRN has become an effective deliverer of e-learning services to teachers and schools across Australia.

Under the DER, the Government is also establishing links with the innovation system through initiatives such as the ICT Innovation Fund. Announced in February 2010, the fund will allocate $20 million to grants for projects to support professional development in ICT for teachers and drive innovation in teaching through school leadership. This initiative recognises the importance of capable, confident and innovative educators in Australia's innovation system.

Through the ICT Innovation Fund, the provision of digital learning resources and the other elements of the DER, the Government is working collaboratively to effect meaningful and sustainable change in Australian schools.

New South Wales

Apps4NSW

Apps4NSW is a public competition that encourages software developers to devise new and innovative methods of storing, using and analysing NSW Government data through cutting-edge technologies. The overriding objective is to make NSW Government information accessible and easily usable for citizens, businesses and community groups.

Apps4NSW is running from November 2009 to April 2010. It includes $100,000 in prizes and development funds to be awarded to individuals and groups who submit ideas and software prototypes that use government data for applications to be used on websites, web services and mobile devices, including smart phones. The competition recognises ideas for applications or services based on public or government data; ideas by school students; and prototype software applications that demonstrate the idea in action. This competition will foster collaboration between NSW citizens and the NSW Government as well as promote and highlight innovation in the digital media sector.

Framework of Principles for Innovation Initiatives

The Framework of Principles for Innovation Initiatives is a first for Australian innovation collaboration. It is a policy guide for governments across Australia to help improve the design, delivery and evaluation of programs that support innovation. The framework was adopted by the Australian Government in May 2009 (see *Powering Ideas*) and by all state and territory governments on 4 December 2009.

The framework is designed to improve the innovation services provided by governments around Australia, such as facilitating access to grants and other innovation assistance by reducing the compliance burden for applicants. The framework is also designed to avoid overlap between state, territory and Commonwealth programs now and in the future, and to help businesses to find the programs that best fit their needs.

The Framework of Principles

1. The innovation initiative supports the development and effectiveness of the National Innovation System
2. The innovation initiative reflects and responds to identified demand side needs and/or priorities
3. The rationale for intervention and the role of government is clearly identified, and supported by best available evidence, where relevant
4. The best placed jurisdiction(s) will be responsible for design and delivery
5. Innovation risk is assessed, accepted and incorporated into the design of innovation initiatives
6. Initiatives are well designed, with clarity about: purpose; expected outcome; key performance indicators; evaluation processes to assess return on investment (financial, economic, environmental or social); and user/target groups
7. Initiatives are designed with end-users in mind, taking into consideration issues such as: accessibility, eligibility criteria, application processes, compliance burden, and the responsibilities of successful applicants
8. Innovation initiatives are evaluated against their own objectives and for impact on the regional or national innovation system.

business.gov.au

The award-winning business.gov.au website has been an invaluable online resource for businesses in Australia for over eleven years and continues to demonstrate innovative approaches to helping businesses deal with government.

A new version of business.gov.au was launched in November 2009. It includes Grant Finder, a new, intuitive way for businesses to discover grants and assistance from the Commonwealth, states and territory governments. Grant Finder is a response to a recommendation of the 2008 Review of the National Innovation System that "governments together develop a single mechanism (such as a web portal) for providing information to clients about access to the full range of Commonwealth and state and territory innovation programs." This recommendation was accepted as an action item in *Powering Ideas*.

The SmartForms component of business.gov.au provides a range of online services to help government agencies meet their advanced online form requirements. SmartForms allow government agencies to replace static forms with a streamlined, automated forms submission process. SmartForms offer significant benefits to both users and government agencies, including reduced time to complete forms, reduced number of forms, reduced turnaround time and costs, improved accuracy and increased security.

In 2009, a payments gateway was added to the SmartForms to provide a complete end-to-end forms processing solution for government agencies. Recent market research found that business.gov.au has strong recognition among businesses and intermediaries and can save a business up to $5,000 and sixteen hours per year.

CASE STUDIES: STATE AND TERRITORY GOVERNMENTS

Victoria

Smart SMEs Market Validation Program

In 2008-09, the Victorian Government started implementing the Smart SMEs Market Validation Program. This $28 million competitive grants program supports SMEs to develop innovative products, processes and services which meet the technology needs of Victorian public sector entities.

The program targets innovations which will lead to the creation of new, commercially-oriented intellectual property. The Victorian public sector organisations become the customers. They define their needs and SMEs are selected on merit to receive R&D grants to develop technology solutions which are then implemented and piloted. New technology solutions may include biotechnology, ICT, nanotechnology or software development. The SMEs retain the ownership of their new intellectual property and government is licensed to use it.

The first round of the program began in March 2009, with twenty-seven government agencies submitting seventy-four technology requirement specifications. A recommended list of nineteen specifications progressed to the second stage. Successful applicants will be announced in 2010.

New South Wales

Intersect

Intersect is a not-for-profit company established by seven NSW universities, through a grant by the NSW Government, to provide e-research services. These services apply ICT to improve research processes and outcomes, and to enable new kinds of research. Intersect is an active contributor to federal initiatives to improve e-research capabilities and infrastructure across Australia. By providing technical services and enhancing institutional capabilities, Intersect is making a major contribution to public sector innovation, and increasing the international competitiveness of NSW research organisations.

Since its foundation in 2008, Intersect has delivered common ICT platforms; support for sharing of data necessary for research and policy development; frameworks for enhanced collaboration; and professional development and career opportunities to address skill shortages. Projects undertaken by Intersect demonstrate its philosophy of seeking collaborative, cross-disciplinary solutions. For example, the Genomic Data Management project will benefit many institutions and research disciplines by making effective use of gene sequencers linked with centralised computational and storage facilities.

With a staff of forty software engineers, IT specialists and e-research analysts, Intersect is working strategically with research organisations in all jurisdictions to develop a user-informed and robust infrastructure for the long-term storage and management of research data.

CHAPTER SIX

Opportunities and challenges

Australia has long enjoyed one of the world's highest standards of living. Improving our innovation performance is critical to maintaining this prosperity in the twenty-first century.

Increasing global economic competition, rapid development of knowledge and technology, and pressing social and environmental issues compel Australia to continuously examine the opportunities and challenges it faces to create a more effective and efficient national innovation system. This will prepare Australia to better target its innovation capacities and to unlock its full innovative potential.

In *Powering Ideas*, the Australian Government identified a number of matters warranting further investigation, including implementing a new foresight model, producing a research workforce strategy, and developing a measurement and analytical framework for the Australian innovation system.

New foresight model: securing Australia's future

In 2009, the Prime Minister's Science, Engineering and Innovation Council (PMSEIC) adopted a new model incorporating foresight methodology. This will improve the council's effectiveness and strategic value to government and other stakeholders by providing a robust scientific evidence base to assist decision-makers in dealing with future challenges facing Australia. The model will identify gaps in evidence and activity required to inform decision-makers of potential future impacts of current choices. It will also be a direct conduit at the important interfaces between science and government, and science and society.

The essentials of foresight

Foresight is not forecasting. It does not attempt to estimate or predict the future. Rather it implies an active approach to the future that includes the assumption that much about the future can be created through actions Australia chooses today.

Foresight involves analysing the current situation and the changes that have led to it, discussing and debating how the future will look, and describing possible scenarios. To achieve this, foresight methodology systematically examines longer-term potential futures for science and technology, the economy, the environment and society, to provide a platform for concrete action and decision-making.

There are four main foresight tools: the Delphi survey technique, scenario development, technology roadmapping, and relevance trees. PMSEIC has adopted a combination of scenario development and technology roadmapping. Scenario development creates alternative futures based on a combination of assumptions, facts and trends, while technology roadmapping identifies the necessary technologies to take advantage of social, economic and market advances and develops strategies through which technology can be accessed.

PMSEIC foresight process

Figure 1 provides an outline of the PMSEIC foresight process which is managed by the Office of the Chief Scientist. The approach is cross-disciplinary, ensuring a range of views from end-users to practitioners are considered.

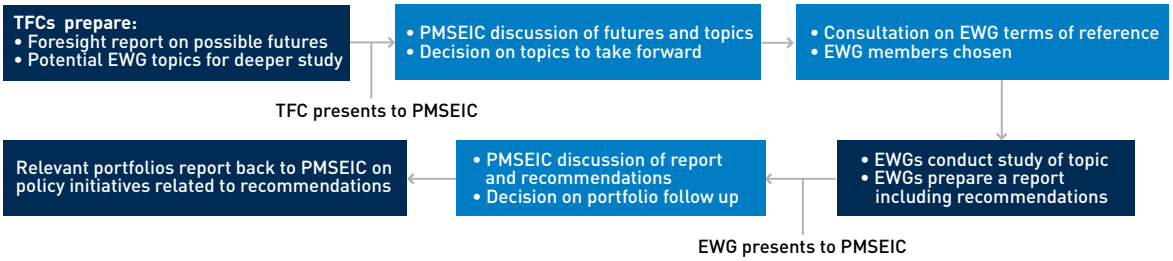
There are four Thematic Foresight Clusters (TFCs), which develop key issues to be addressed by PMSEIC and visions of possible futures. Each cluster focuses on a theme of national importance:

- Climate Change, Energy, Water and Environment: Impact on Australia
- Knowledge Generation, Skills and Perception in a Global World
- National Health, Wellbeing and Security
- Science as an Engine for Innovation in Commerce, Industry and the Arts.

The clusters also suggest topics for further examination by Expert Working Groups (EWGs). These topics are important issues that need to be understood in order to meet the challenges or opportunities represented by the anticipated futures. Once approved by PMSEIC, terms of reference are drawn up in consultation with government departments and the working groups commence studying the chosen topic over six to twelve months.

The working group prepares a report which includes recommendations for immediate and medium-term action that will ensure positive outcomes in the futures anticipated by the thematic foresight cluster. PMSEIC discusses the recommendations and their implications for current and future Government action. Ministers are required to report back to PMSEIC on initiatives undertaken to address the working group recommendations.

Figure 1: An outline of the PMSEIC foresight process



Early foresight progress

By the end of 2009 all four thematic foresight clusters had been established and two have presented their foresight reports to PMSEIC. Two working groups are conducting studies on approved deeper topics and will present to PMSEIC in the first half of 2010, as will the remaining clusters. The second half of the year will see a further working group topic presented to PMSEIC related to the National Health, Wellbeing and Security cluster.

In addition to this progress on process development and program initiation, PMSEIC foresight activity has extended its reach within the Australian Government and wider global community. Ongoing dialogue has been initiated with numerous countries interested in sharing best practice on foresight methodology, experience and data. Within the Australian Government, a number of departments have expressed an interest in learning about PMSEIC's methodology with a view to adopting techniques to support their policy efforts.

While the model is still at a formative stage, it is anticipated that the new approach will become world-class with the assistance of colleagues in other countries and experts in foresight methodology. Presentations to the PMSEIC standing committee on foresight methodology successfully used by others are planned, and these will be used to refine the current approach. The approach will continue to provide evidence-based scientific recommendations that can be used by government in decision-making, leading to long-term improvements in the productivity, security and sustainability of Australia.

The Australian Government's Research Workforce Strategy

In *Powering Ideas* the Australian Government committed to take steps to meet Australia's research workforce challenges through the development of a research workforce strategy. The overarching objective of the strategy is to develop a strong and productive research workforce to support the Government's reform agenda for innovation and higher education in Australia and contribute to the productivity gains which will ultimately underpin Australia's future prosperity.

In support of this, the strategy will:

- respond to issues raised in *Powering Ideas, Building Australia's Research Capacity* and *Transforming Australia's Higher Education System* that relate to Australia's research workforce
- support Australia in meeting the Government's goals to "progressively increase the number of research groups performing at world class levels" and "significantly increase the number of students completing higher degrees by research over the next decade"
- address anticipated shortfalls in the future supply of research-qualified people in Australia.

The strategy will cover the decade to 2020, considering the key challenges and opportunities for Australia's research workforce and mechanisms to address them. Work on the strategy is expected to be completed in the second half of 2010.

Recent progress and emerging themes

A reference group comprising representatives from the university sector, the National Tertiary Education Union, peak industry groups, government departments and statutory bodies, professional organisations and societies, the National Academies Forum, and postgraduate student associations has been established to support the strategy development process. The reference group is chaired by the Department of Innovation, Industry, Science and Research.

Three subgroups of the reference group have been established to progress work in areas critical to developing an understanding of Australia's current and future research workforce needs: employer demand, research training experience, and research career pathways.

Employer demand

Major employers of research workers include both private industry and public sector research organisations. It is important that the supply of research-qualified individuals, whether through the research training system or through immigration, matches employer demand, both in the number and types of skills available.

There are a number of factors that present challenges in this regard, including:

- changes in the quantity and nature of skills sought by employers in Australia
- the global nature of demand, arising from the increasing internationalisation of research and innovation activity
- the demographic characteristics of Australia's current research workforce, which suggest significant replacement demand in key sectors such as academia due to age-related retirements in the next ten to fifteen years.

The Government has commissioned two studies to inform understanding of these issues. The first, *Employer demand for researchers in Australia*, explored characteristics of employers' existing research workforces, skill requirements and strategies to access skills, and anticipated demand for researchers into the future. This study was completed in March 2010. The second study, *Australia's Future Research Workforce: Supply, Demand and Influence Factors*, will examine Australia's future supply of and demand for higher degree by research qualifications, taking into account different scenarios for Australia over the next decade.

The research training experience

Graduating higher-degree students, whether domestic or international, are one of the main sources of the supply of trained researchers to Australia's workforce. It is important that the research training system is able to attract and retain the most promising students and provide them with the skills required for a diverse range of careers.

A House of Representatives inquiry into research training and research workforce issues in Australian universities made a number of recommendations for Australia's research workforce in its 2008 report.[53] The Australian Government response to the inquiry referred several issues raised in the report to the strategy. These issues are being examined by the Research Training Experience subgroup in consultation with student groups, universities and other stakeholders.

Research career pathways

A researcher's career stretches from managing the early transition from higher-degree training into employment, establishing a profile and consolidating skills as an early career researcher, through to mid and late career stages. Each of these transitions and stages involves different challenges and different opportunities. Creating viable career pathways will involve:

- promoting mobility between the public and private sectors
- accommodating family responsibilities within research careers
- providing the right balance in employment between security, agility and flexibility.

These issues are being examined by the research career pathways subgroup in consultation with stakeholders, including targeted roundtables with people at different stages of research careers in Australia.

Measurement and analytical framework for the national innovation system

In Australia, as in many OECD countries, governments have been providing substantial support for R&D and innovation in their national budgets over many years. The ability to better account for the effectiveness of these expenditures and to improve policy coordination across government requires a deeper understanding of the dynamics of the innovation process than can be provided by a few commonly used stock indicators. Five decades of innovation-related data is now available to inform policy makers as they undertake contemporary policy formulation.

With these issues in mind, and in response to a recommendation of the Review of the National Innovation System, the Department of Innovation, Industry, Science and Research commissioned work on measuring innovation activities and policy efforts. This work has been compiled as the Innovation Metrics Framework and aims to develop consistent guidelines for innovation measurement, program data collection and analysis that are relevant to Australia's needs and reflect current best practice. The work also incorporates recent thinking on innovation measurement and analysis, drawing on work done internationally and locally.

53 House of Representatives Committee on Industry, Science and Innovation (2008), *Building Australia's Research Capacity*, Parliament of the Commonwealth of Australia Canberra, December 2008.

The lessons emerging from the OECD's 2006 Blue Sky II Conference serve as a starting point for considering the directions of the project and the recommendations of the OECD's measurement frameworks form key building blocks of the project.

The approach taken for conceptualising a framework capable of supporting analysis needed for innovation policy is summarised in Figure 2.

At the centre of the structure are the OECD definitional and measurement frameworks for innovation activities. Their association with the other technical fields, as shown in Figure 2's structure, is intended to highlight the importance of conceptual consistency with related research fields since these technical fields not only provide the theoretical frameworks but also the requisite tools for testing data outputs.

The *Innovation Metrics Framework* provides guidelines for:

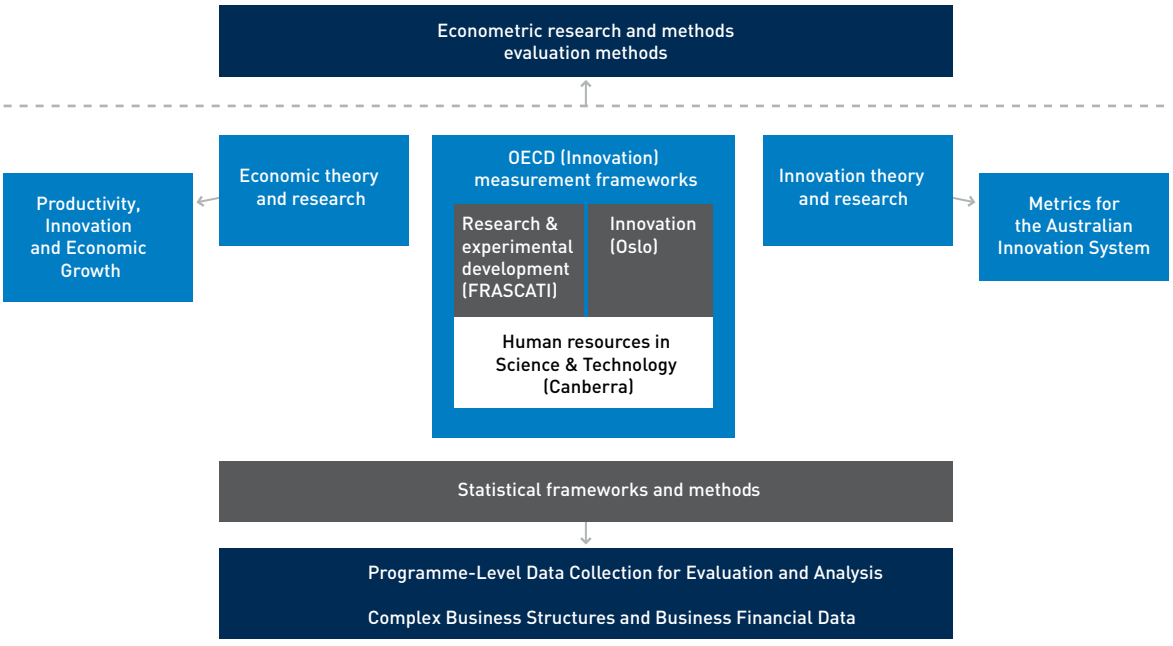
- developing of indicators at the national innovation system level
- program-level data collection and evaluation
- developing quality innovation statistics.

Development of indicators at the national innovation system level

New challenges and changing policy priorities drive the need to supplement traditional innovation indicators with new indicators that better reflect innovation as a system of interacting activities. There are five main implications of Australia's economic characteristics and future challenges for innovation metrics:

- Policy development and evaluation require a set of innovation metrics that can tell the full story of how innovation occurs in the business and public sectors
- Metrics need to be relevant to the Australian economic and innovation context
- New metrics are required for knowledge flows and for how firms innovate
- There is a need for metrics for those components of the national innovation system that are not captured by traditional indicators
- International benchmarking and comparisons of Australian innovation metrics with metrics from other countries need to be made carefully.

Figure 2: Conceptual elements taken into account in the *Innovation Metrics Framework*



Program-level data collection and evaluation

Program data are collected primarily for administrative and reporting purposes. With increasing interest in adopting more evidence-based and systematic approaches to policy development and program evaluation, there is also pressure for these same data sets to satisfy analytical research purposes.

For the program data to be useful for analysis and evaluation and to minimise compliance costs, the data collection methodologies should be guided by the following principles.

- Collect and define program data based on accepted international measurement frameworks to ensure consistency and comparability over time and across datasets.
- The objectives of the program should be defined in sufficient detail so that reliable longitudinal data can be developed, starting from the application (i.e. ex ante data).
- For business data, collection of the unique identifier, the Australian Business Number (ABN), and information about the relationship of the reporting entity to other associated entities, are essential for identifying the statistical unit, for data matching, and for dealing with complications associated with changes to business structure, exits and entries.
- The data collection strategy should anticipate the needs of possible future analysis or evaluation to ensure that the data is of an appropriate quality, of which consistent definition and classification are an important aspect.
- Collect only what is needed in order to minimise administrative and provider burden.

Developing quality innovation statistics

The Australian Bureau of Statistics (ABS) is responsible for the collection and definition of national innovation statistics in Australia. In order to produce coherent and robust statistics and innovation statistics in particular, the ABS uses:

- consistent and well-defined classifications
- a common survey frame (i.e. list of businesses), which accurately describes the target population
- consistent and well-defined standards (e.g. methods, processes).

The development of quality innovation statistics in the context of the metrics framework focuses on the use and implementation of the ABS units model for defining and classifying businesses. The units model includes principles for relating business financial data to economic concepts.

Future work on innovation metrics

Future work will concentrate on:

- Developing composite indicators in the areas of knowledge flows in the innovation system and how firms innovate
- Developing new data and indicators for the Business Characteristics Survey. The Innovation Metrics Framework proposes a list of possible indicators in these two areas. Most composite indicators require cross-tabulation of the Business Characteristics Survey dataset and this will need to be done by, or in collaboration with, the ABS
- Improving program-level data collection and analysis. One of the most promising areas for future work is the study of econometric models that shed light on the relationships between different types of innovation modes and economic performance. Innovation modes may be constructed based on different types of policy programs. Findings from these econometric studies may be very useful from a policy perspective. The OECD is also conducting research in this area.

Other areas for future work on innovation indicators include public sector innovation, environmental innovation, entrepreneurship and innovation demand.

These are frontier areas in the development of new innovation indicators. The Department of Innovation, Industry, Science and Research is collaborating with the OECD and following closely the developments in these four areas. The department expects to be incorporating new indicators in these areas in future publications.

ABBREVIATIONS

AAT	Anglo-Australian Telescope
ABS	Australian Bureau of Statistics
ACCESS	Australian Community Climate and Earth-System Simulator
ACIS	Automotive Competitiveness and Investment Scheme
AISRF	Australia-India Strategic Research Fund
ANSTO	Australian Nuclear Science and Technology Organisation
APA	Australian Postgraduate Awards
APAI	Australian Postgraduate Awards (Industry)
ARC	Australian Research Council
ASRP	Australian Space Research Program
BCS	Business Characteristics Survey
BERD	Business expenditure on research and development
CCS	Carbon capture and storage
CEI	Clean Energy Initiative
CERF	Commonwealth Environment Research Facilities
CIRM	California Institute for Regenerative Medicine
COD	Chemical oxygen demand
CoML	Census of Marine Life
CPRS	Carbon Pollution Reduction Scheme
CRC	Cooperative Research Centre
CReefs	Census of Coral Reefs
CRN	Collaborative Research Networks
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAC	Darwin Aquaculture Centre
DEEWR	Department of Education, Employment and Workplace Relations
DER	Digital Education Revolution
DIISR	Department of Innovation, Industry, Science and Research
DSARC	Defence and Security Applications Research Centre
DSTO	Defence Science and Technology Organisation
EIF	Education Investment Fund
EPI	Environmental Performance Index
ERA	Excellence in Research for Australia
EU	European Union
EWG	Expert working group
FESA	Fire and Emergency Services Authority of Western Australia
GA	Geoscience Australia
GBAORD	Government budget appropriations or outlays on research and development
GCI	Global Competitiveness Index
GCIF	Green Car Innovation Fund
GERD	Gross expenditure on research and development
GDP	Gross domestic product
GFC	Global financial crisis
GOVERD	Government expenditure on research and development
GVA	Gross value added
HDI	Human Development Index
HDR	Higher degree by research
HERD	Higher education expenditure on research and development
HESA	Higher Education Support Act 2003

ICRAR	International Centre for Radio Astronomy Research
ICT	Information and communication technology
IGS	Institutional Grants Scheme
IIF	Innovation Investment Fund
IIFF	Innovation Investment Follow-on Fund
IMF	International Monetary Fund
IP	Intellectual property
IPO	Initial public offering
IPRS	International Postgraduate Research Scholarships
ISL	International Science Linkages
JRE	Joint Research Engagement
MAC	Management Advisory Committee
MDPP	Medical Devices Partnering Program
MFP	Multifactor productivity
MOU	Memorandum of understanding
MVP	Motor vehicle producers
MW	Megawatt
NARP	National Adaptation Research Plans
NCGP	National Competitive Grants Program
NDLRN	National Digital Learning Resources Network
NHMRC	National Health and Medical Research Council
NICTA	National ICT Australia
NIMPSI	New Initiative to Measure Public Sector Innovation
OECD	Organisation for Economic Co-operation and Development
PCT	Patent Cooperation Treaty
PFRA	Publicly funded research agency
PFRO	Publicly funded research organisation
PMSEIC	Prime Minister's Science, Engineering and Innovation Council
PPP	Purchasing power parity
R&D	Research and development
RDC	Research and Development Corporation
RET	Renewable Energy Target
RiB	Researchers in Business
S&E	Science and engineering
SEO	Socio-economic objective
SKA	Square Kilometre Array
SME	Small and medium enterprise
SRE	Sustainable Research Excellence
TAS	Tailored Advisory Service
TFC	Thematic Foresight Cluster
TKC	Technology and Knowledge Connect
TPER	Technology Partnerships Equipment Register
TRS	Technology Requirement Specifications
TTCF	Trans Tasman Commercialisation Fund
UNSW	University of New South Wales
VICOSC	Victorian Organic Solar Cell Consortium
VNI	Victorian Neurotrauma Initiative
WIIN	Workshops Industry Intelligence and Networking
WIP	Workforce Innovation Program
WIPO	World Intellectual Property Organization
WLAN	Wireless Local Area Networking

APPENDIX 1

Selected website links to Australia's innovation system

Below are links to innovation related programs or initiatives undertaken by major players of the national innovation system as provided in the report[54]. The list also includes links, where available, to further information on the case studies.

Commonwealth Government departments

Department of Agriculture, Fisheries and Forestry

www.daff.gov.au

- Rural Research and Development Corporations
  www.ruralrdc.com.au

Department of Broadband, Communications and the Digital Economy

www.dbcde.gov.au

- National ICT Australia
  www.nicta.com.au

Department of Climate Change

www.climatechange.gov.au

- Carbon Pollution Reduction Scheme
  www.climatechange.gov.au/en/government/initiatives/cprs
- National Climate Change Adaptation Research Facility
  www.climatechange.gov.au/government/initiatives/national-climate-change-adaptation-research-facility
- Renewable Energy Target
  www.climatechange.gov.au/en/government/initiatives/renewable-target

Department of Education, Employment and Workplace Relations

www.deewr.gov.au

- Digital Education Revolution
  www.deewr.gov.au
  schoolingDigitalEducationRevolution
- Education Investment Fund
  www.deewr.gov.au/HigherEducation/Programs/EIF
- Workforce Innovation Program
  www.deewr.gov.au/WIP

Department of the Environment, Water, Heritage and the Arts

www.environment.gov.au

- Commonwealth Environment Research Facilities
  www.environment.gov.au/about/programs/cerf

Department of Finance and Deregulation

www.finance.gov.au

- Excellence in e-Government Award
  www.finance.gov.au/e-government/better-practice-and-collaboration/e-government-awards.html

Department of Infrastructure, Transport, Regional Development and Local Government

www.infrastructure.gov.au

- Australian Centre of Excellence for Local Government
  www.infrastructure.gov.au/local/centre_of_excellence
- National Awards for Local Government
  www.infrastructure.gov.au/local/awards

Department of Innovation, Industry, Science and Research

www.innovation.gov.au

- Key programs and services
  www.innovation.gov.au/Industry/Pages/KeyProgramsandServices.aspx
  - Clean Business Australia
  - Collaborative Research Networks program
  - Commercialisation Australia
  - Cooperative Research Centres Program
  - Enterprise Connect
  - Green Car Innovation Fund
  - Innovation Investment Follow-on Fund
  - Innovation Investment Fund
  - International Science Linkages Program
  - Joint Research Engagement
  - R&D Tax Concession
  - Super Science Initiative

54 This is not an exhaustive list and should be used as a guide only.

- Other programs, projects and services
  - Australia-India Strategic Research Fund https://grants.innovation.gov.au/AISRF
  - Australian Postgraduate Awards www.innovation.gov.au/Section/Research/Pages/australian_postgraduate_awards_scheme.aspx
  - Australian Space Research Program www.innovation.gov.au/Industry/Space/Pages/AustralianSpaceResearchProgram.aspx
  - International Postgraduate Research Scholarships www.innovation.gov.au/Section/Research/Pages/InternationalPostgraduateResearchScholarships.aspx
  - Mission Based Compacts www.innovation.gov.au/Section/Research/Pages/Mission-BasedCompacts.aspx
  - National Enabling Technologies Strategy www.innovation.gov.au/enablingtechnologies
  - Prime Minister's Prizes for Science https://grants.innovation.gov.au/SciencePrize/Pages/Home.aspx
  - Research Workforce Strategy www.innovation.gov.au/Section/Research/Pages/ResearchWorkforceIssues.aspx
  - Space Policy Unit www.innovation.gov.au/Industry/Space/Pages/SpacePolicyUnit.aspx
  - Sustainable Research Excellence in Universities www.innovation.gov.au/Section/Research/Pages/SustainableResearchExcellence(SRE).aspx
- Councils and Committees
  - Commonwealth, State and Territory Advisory Council on Innovation www.innovation.gov.au/Section/Innovation/Pages/CommonwealthStateandTerritoryAdvisoryCouncilonInnovation(CSTACI).aspx
    - Framework of Principles for Innovation Initiatives www.innovation.gov.au/innovationframework
  - Industry Innovation Councils www.innovation.gov.au/IndustryInnovationCouncils
    - Innovation Profiles www.innovation.gov.au/innovationprofiles
  - Australian Public Service Management Advisory Committee www.apsc.gov.au/mac
    - Advancing Public Sector Innovation www.innovation.gov.au/Section/Innovation/Pages/AdvancingPublicSectorInnovation.aspx
  - Business.gov.au www.business.gov.au

Department of Resources, Energy and Tourism

www.ret.gov.au

- Clean Energy Initiative www.ret.gov.au/energy/energy%20programs/cei/Pages/default.aspx

Commonwealth Government agencies

Anglo-Australian Observatory[55]

www.aao.gov.au

Australian Institute of Marine Science

www.aims.gov.au

- Census for Coral Reefs www.creefs.org

Australian Nuclear Science and Technology Organisation

www.ansto.gov.au

- Centre for Accelerator Science www.ansto.gov.au/research/institute_of_environmental_research/science/accelerator_science/centre_for_accelerator_science

Australian Research Council

www.arc.gov.au

- National Competitive Grants Program www.arc.gov.au/ncgp/default.htm
- Excellence in Research for Australia www.arc.gov.au/era/default.htm

Australian Trade Commission (Austrade)

www.austrade.gov.au

Bureau of Meteorology

www.bom.gov.au

Commonwealth Scientific and Industrial Research Organisation

www.csiro.au

55 From 1 July 2010, new governance arrangements will take effect and the Anglo-Australian Observatory will be renamed the Australian Astronomical Observatory.

- Australian Growth Partnerships Program
  www.csiro.au/partnerships/AGP.html
- National Research Flagships Program
  www.csiro.au/partnerships/NRF.html
- Printable solar cells
  www.csiro.au/news/Trials-for-printable-plastic-solar-cells.html
- Small and Medium Enterprise Engagement Centre
  www.csiro.au/solutions/SMEEngagement.html

Defence Science and Technology Organisation

www.dsto.defence.gov.au

Geoscience Australia

www.ga.gov.au

- Tsunami Research Reports
  www.ga.gov.au/hazards/tsunami/reports.jsp

IP Australia

www.ipaustralia.gov.au

- IP Rights Reforms
  www.ipaustralia.gov.au/resources/news_new_archived_2009.shtml#77

National Health and Medical Research Council

www.nhmrc.gov.au

- Centres of Research Excellence
  www.nhmrc.gov.au/grants/apply/cre/index.htm
- Program Grants
  www.nhmrc.gov.au/grants/types/granttype/programs.htm
- Project Grants
  www.nhmrc.gov.au/grants/apply/projects/index.htm

Office of the Chief Scientist

www.chiefscientist.gov.au

- Prime Minister's Science, Engineering and Innovation Council
  www.innovation.gov.au/ScienceAndResearch/prime_ministers_science_engineering_innovation_council/Pages/default.aspx

Questacon

www.questacon.edu.au

- Questacon Smart Moves Invention Convention
  www.smartmoves.questacon.edu.au
- Inspiring Australia: a national strategy for engagement with the sciences
  www.innovation.gov.au/General/Corp-MC/Pages/InspiringAustralia.aspx

State and territory government

Australian Capital Territory

www.act.gov.au

- Australian e-Government Technology Cluster
  www.nicta.com.au/business/market_engagement/industry_clusters/egovcluster
- InnovationConnect
  www.business.act.gov.au/doing_business_in_canberra/business_grants_and_assistance/innovationconnect

New South Wales

www.nsw.gov.au

- Apps4NSW
  www.information.nsw.gov.au/apps4nsw
- Institute for Transdisciplinary eResearch Services and Technology (Intersect)
  www.intersect.org.au
- Life Sciences Research Awards
  www.researchroadmap.osmr.nsw.gov.au/Sectors/LifeSciences/FundingAndSupport/A.5.1.5.htm
- TechVouchers
  www.business.nsw.gov.au/techvouchers

Northern Territory

www.nt.gov.au

- Aquaculture
  www.nt.gov.au/d/Fisheries/index.cfm?header=Aquaculture

Queensland

www.qld.gov.au

- Smart Futures Fund
  www.industry.qld.gov.au/smartfuturesfund
- Ulysses – transforming business through design
  www.industry.qld.gov.au/dsdweb/v4/apps/web/content.cfm?id=14398

South Australia

www.sa.gov.au

- Innovate SA
  www.innovatesa.com.au
- Medical Devices Partnering Program
  www.mdpp.org.au
- The Plant Accelerator
  www.plantaccelerator.org.au
- Trans Tasman Commercialisation Fund
  www.ttcf.com.au

Tasmania

www.tas.gov.au

- Springboard Accelerator Program – Business Incubation Services www.thespringboard.com.au

Victoria

www.vic.gov.au

- Smart SMEs Market Validation Program www.business.vic.gov.au/BUSVIC/STANDARD/PC_63422.html
- Victoria-California Stem Cell Alliance www.business.vic.gov.au/BUSVIC/STANDARD/1001/PC_63759.html
- Victoria's Science Agenda Investment Fund www.business.vic.gov.au/BUSVIC/STANDARD/PC_63087.html

Western Australia

www.wa.gov.au

- Western Australian Energy Research Alliance www.waera.com.au
- Western Australian Marine Science Institution www.wamsi.org.au
- Centre for Food and Genomic Medicine www.cfgm.org.au
- International Centre for Radio Astronomy Research www.icrar.org

Other organisations

Association of Australian Medical Research Institutes

www.aamri.org

Australian Business Foundation

www.abfoundation.com.au

Australian National Audit Office

www.anao.gov.au

- Better Practice Guide – Innovation in the Public Sector www.anao.gov.au/bpg-innovation/contents.html

Research Australia

www.researchaustralia.org

- Dr Jerome Maller, Victorian Neurotrauma Initiative Early Career Research Fellow www.vni.com.au/capacitybuilding/cid/231/parent/0/pid/6/t/capacitybuilding/title/dr-jerome-maller

Universities Australia

www.universitiesaustralia.edu.au

Websites for business case studies

Aqua Diagnostic

www.aquadiagnostic.com

Deloitte Touche Tohmatsu

www.deloitte.com.au

- Innovation program www.deloitte.com/view/en_AU/au/article/26495915531fb110VgnVCM100000ba42f00aRCRD.htm

OneSteel

www.onesteel.com

Simavita

www.simavita.com

Tantalus

www.tantalus.com.au

Textor Technologies Pty Ltd

www.textortextiles.com

Websites for university case studies

Charles Darwin University

www.cdu.edu.au

Monash University

www.monash.edu.au

- Ofidium www.ofidium.com

New South Innovations – University of New South Wales

www.nsinnovations.com.au

- Technology that converts fly ash into lightweight building product www.youtube.com/watch?v=HzXimHnDkiY&feature=channel_page

UniQuest – University of Queensland

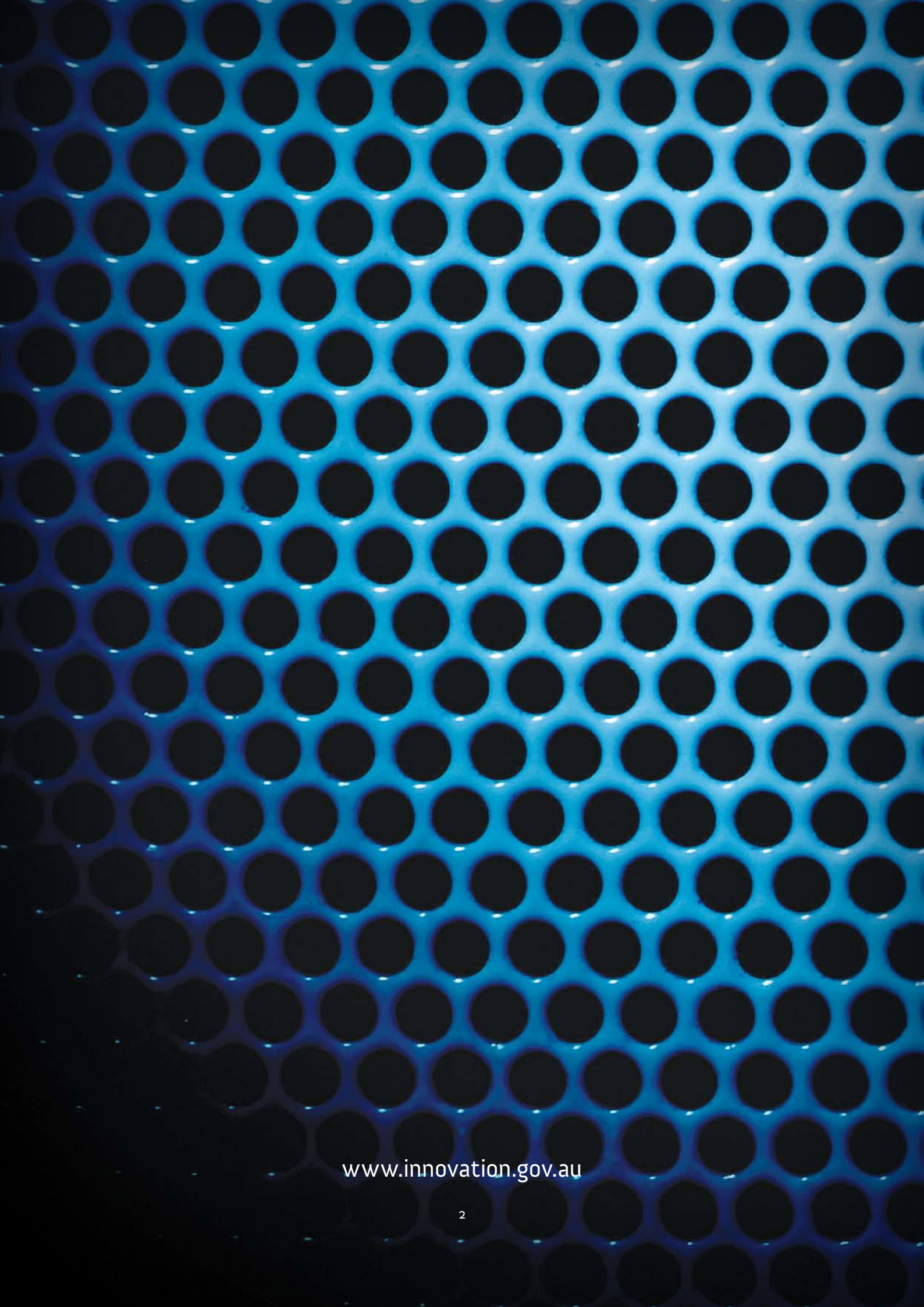
www.uniquest.com.au

- QRxPharma Limited www.qrxpharma.com

University of Adelaide

www.adelaide.edu.au

- Surveillance software solves security snag www.adelaide.edu.au/adelaidean/issues/35861/news35874.html



www.innovation.gov.au