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INNOVATION

Australian Innovation
System Report • 2013



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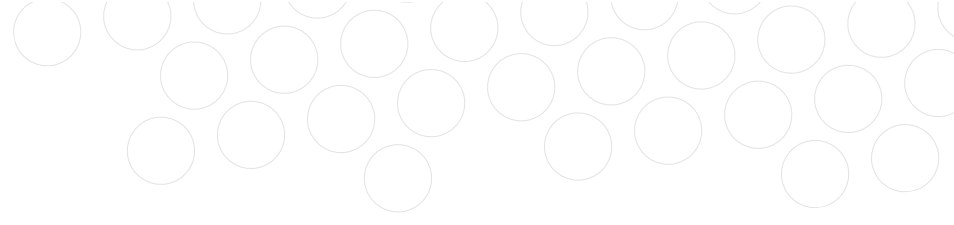
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ACRONYMS

ABS	Australian Bureau of Statistics
APEC	Asia Pacific Economic Cooperation
AWPA	Australian Workforce and Productivity Agency
BERD	Business expenditure on research and development
CE	Cambridge Econometrics
CPA	Certified Public Accountants
CRC	Cooperative Research Centres
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DFAT	Department of Foreign Affairs and Trade
DIISR	Department of Innovation, Industry, Science and Research
DIISRTE	Department of Industry, Innovation, Science, Research and Tertiary Education
DIICCSRTE	Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education
DSEWPaC	Department of Sustainability, Environment, Water, Population and Communities
GE	General Electric
GFC	Global financial crisis
GERD	Gross expenditure on research and development
GDP	Gross Domestic Product
GHK	GHK Consulting
GOVERD	Government expenditure on research and development
GVCs	Global value chains
HDR	Higher degree research
HERD	Higher education expenditure on research and development
IEEP	Institute for European Environmental Policy
INSEAD	European Institute of Business Administration
IMD	International Institute for Management Development (Business School, Switzerland)
IHDP	International Human Dimension Programme on Global Environmental Change
IMF	International Monetary Fund
LCEGS	Low carbon environmental goods and services
OECD	Organisation for Economic Co-operation and Development
PFRA	Publicly funded research agency
PM&C	Department of Prime Minister and Cabinet
R&D	Research and development
SME	Small and medium enterprises
UNEP	United Nations Environment Programme
UNU	United Nations University
UoE	Unit of Evaluation
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

EXECUTIVE SUMMARY

Australian innovation and engagement with Asia is the theme of the *Australian Innovation System Report 2013*, the fourth in a series of Australian Government reports on the Australian innovation system. The core message of this report is that the rise of Asia presents many opportunities for Australia beyond the resources sectors. Seizing these opportunities will require an economy that is flexible, resilient and embraces market diversification. To achieve this, the comparative advantage of Australia's proximity to Asia needs to be complemented with its competitive advantages in innovation and better knowledge of Asian markets.

This report continues, where possible, to update indicators established in previous reports and add new insightful indicators that show trends in the innovation system. Many of these indicators benchmark Australia's innovation performance against other countries, primarily Organisation for Economic Co-operation and Development (OECD) countries.

The performance of the Australian innovation system

A high performing national innovation system is one that delivers productivity gains and social and environmental outcomes, leading to improved living standards. Compared to other developed countries Australia enjoys high living standards and is progressively closing the gap with the top five OECD countries in terms of Gross Domestic Product (GDP) per capita and GDP per hour worked. Australia's overall competitive position, reflected by the Global Competitiveness Index, is high in the world (20th out of 144 countries) although moderate among the OECD countries (15th out of 34 countries). Australia has consistently maintained a high ranking in the Human Development Index – second only to Norway.

Australian economic engagement with Asia has increased in the last decade. Indices and aggregate statistics of trade investment and exchange of skilled people show that Australia is one of the countries taking advantage of the rise of Asia. A deeper analysis suggests, however, that this engagement has been uneven. Sectoral, regional and business size data shows that the drivers of engagement with Asia are large businesses and organisations in mining, primary sectors such as agriculture and education services. Many small and medium enterprises (SMEs) in other industries have been unable to seize the opportunities of Asian growth.

Two factors are fundamental to successful engagement with Asia – innovation capacity and knowledge of Asian markets. As Asian businesses and customers become more sophisticated, competition will be increasingly driven by innovation. New-to-the-world innovation is essential for competing in markets for high value-added goods and services and is also strongly linked with business use of science and engineering skills and industry research collaboration. Some Australian businesses are responding to this challenge by incorporating high value-added services as part of their offering. Encouragingly, the latest data on the percentage of innovation-active businesses reached its highest recorded value of 46.6% in 2011–12. However, previous analysis has shown that most innovation is incremental in nature, comprising the adoption or modification of existing innovations with new-to-the-world innovation being only a small proportion of total innovations. This is in sharp contrast to other developed economies that have a much higher proportion of new-to-the-world business innovation and relatively high trade volumes.

Comparisons of select Australian industries with European counterparts rank Australian SMEs high on innovation. For example, the proportion of Australian manufacturing SME businesses that are innovating was ranked second. In spite of these relatively higher levels of innovation, data shows that SMEs have difficulty in entering international supply chains, reflecting low levels of export activity compared with large businesses.

SMEs are lean innovators, accounting for a very small share of total investment in innovation, and are much less likely to generate new-to-the-world innovations. By contrast, large Australian businesses make up the majority of total investment in innovation, are much more likely to collaborate with the research sector and generate new-to-the-world innovations. While large Australian businesses also generally display higher levels of innovation than Australian SMEs, when compared with their European counterparts, they are below average innovators across most industries.

Large businesses are responsible for the majority of export value, investment in innovation and generation of world-first innovations, yet represent a sector of the economy with a relatively poor innovation performance. The data suggests potential inefficiencies in the innovation system or, at least, very different strategic intent behind large business investments in innovation. Although better data is needed to contrast innovation frequency and impact, this result has implications for Australia's ability to capture rapidly maturing Asian markets with innovative goods and services.

The report suggests the need for improved business culture and management capacity that will enable us to provide innovative solutions for Asian customers and supply chains. Part of the challenge is to increase collaboration and productive linkages that will allow Australian businesses to compete based on innovation. A high-performing innovation system should ensure that actors within the system are connected and able to effectively collaborate, thereby maximising the flow and exchange of resources and ideas.

As shown in the 2012 Australian Innovation System report, innovation almost doubles the likelihood of productivity growth in Australian businesses. Compared to businesses that don't innovate, innovative Australian businesses are 78% more likely to report increases in productivity over the previous year. An extension of this analysis shows that collaborative innovation with research organisations triples the likelihood of business productivity growth. Compared to businesses that don't innovate, innovative Australian businesses that collaborate with research organisations (amongst others) are 242% more likely to report increases in productivity. Despite this (and other benefits to training and exports), Australia's overall levels of collaborative business innovation and business-to-research collaboration on innovation continue to compare poorly with other OECD countries.

Collaborative innovation is not only a tool for productivity growth. Another, perhaps related impact is on the degree of innovation novelty. Collaborative innovation is significantly correlated with the introduction of new-to-Australia or world-first innovations.¹ Again this raises the concern that Australia needs to lift its aggregate numbers of innovative, collaborative businesses above world standards if it is to effectively take advantage of the rapid maturation of other large Asian economies. This report identifies that:

- A quarter of all innovation-active businesses collaborate on innovation.
- Innovation-active businesses collaborate more than businesses that do not innovate.
- SMEs have caught up with, and even slightly exceeded, large businesses on the levels of innovative collaboration.
- Large businesses collaborate on innovation to a greater extent with universities or other research institutions than SMEs.

This report shows that Australia's economic conditions are strong, upheld by robust economic growth and low unemployment and inflation, particularly in comparison to the developed world. However, indicators of the resilience of the Australian economy have declined because of the perception of an over-dependence of the economy on resource-based sectoral exports to China. The lack of industry diversity is a significant risk to Australia's medium to long term productivity growth and the sustainability of its economy. Previous reports show that productivity growth is largely driven by innovation, which comes from good management of physical and intangible capital investments. Australia can increase its market diversity and, hence, its resilience to global shocks by creating new markets and cornering existing markets with more innovative goods and services. With its near-full employment and some of the longest working hours in the world, the only option for Australia is to work smarter.

Working smarter involves sustained investment in the framework conditions and activities of the national innovation system. Evidence from global comparisons suggests that Australia's innovation system may not be as efficient as other high-performing innovation systems. However, the environment for business innovation and entrepreneurship is very well regarded internationally; its population is highly qualified; its research output and quality relatively high; and its economic conditions excellent.

Australia's Gross expenditure in R&D (GERD) reached a historical high of \$30.8 billion in 2010–11. As a result, its GERD-to-GDP ratio was 2.20% ranking it 11th among OECD countries. Australia's investment in higher education expenditure R&D (HERD) was \$8.2 billion in 2010–11. This represents 0.59 % of GDP up from 0.55%

¹ Australian Government (2006) *Collaboration and other factors influencing innovation novelty in Australian businesses: An econometric analysis*, Department of Industry, Tourism and Resources, Canberra, Australia.

in 2008–09. Compared with OECD countries, Australia improved its ranking from 11th in 2008 to 9th in 2010 on this score.

Australia's bilateral research links with China, Japan and India are strong and keeping pace with the growth in their respective research sectors. Measured by the number of joint publications, Australia was among the top 10 international collaboration partners in research for China, Japan, South Korea and India. These research links with Asian countries complement Australia's growing engagement with Asia in tertiary education.

Australia's research output in terms of publications and citations has also shown improvements, particularly in the OECD, where it ranks relatively high in several indicators of research quality. For example, Australia's share of world publications has improved from 2.61% in 2008 to 3.44% in 2012 and ranks 8th in this indicator in the OECD. The improvement of Australia's share of the top 1% highly cited publications can be attributed largely to international collaboration. Research publications involving international collaboration make up the majority of Australia's world's best research publications (top 1%) and this proportion grew from 2.27% in 2006 to 3.52% in 2012.

Australian international engagement through the tertiary education system has already made significant contributions to the nation's economy and society. Australia's high share of international tertiary student enrolments not only delivers a considerable export income, but also provides an excellent platform for building mutual understanding through people-to-people contacts, social and cultural exchange and business links with the region. The trade and cultural relations that flow from such engagements are important for creating future business opportunities. A favourable environment for student and academic mobility is also important for realising the mutually beneficial opportunities for exchange of new knowledge and ideas through scientific and research collaboration.

Data shows that Australia still relies heavily on US and Europe as a source of ideas, investment, innovation and technology and this relationship should continue to be strong. A high-performing Australian innovation system should be able to build on existing linkages and collaboration to embrace new opportunities in Asian markets.

However, maintaining a high share of the international education market is increasingly challenging. There is strong competition from other OECD countries, as well as countries like China and India. China and India, whose booming higher education markets have benefitted Australia, are investing heavily to meet domestic demand.

Despite all these inputs, Australia's innovation output is not as high as it could be. Critical areas of poor performance identified in this and previous reports, such as collaboration on innovation, business culture or business management skills, need new approaches. Working smarter also means improving our understanding of how major markets such as those in Asia operate. Unfortunately, investing in language, cultural understanding and business experience in Asia seems more important to others than it does to Australian businesses.

One major opportunity from rapidly developing Asian markets is in the development of innovative, environmental goods and services. Billions of dollars worth of export opportunities exist for innovative, first-mover Australian businesses that can meet the rapidly increasing demand for innovative environmental solutions from developing countries such as India, China and Indonesia. To fully benefit from these opportunities, Australia also needs to transition to a more environmentally sustainable economy (so-called *Green Growth*). However, Australia currently and consistently ranks at the bottom of the OECD on environmental performance. Although Australia has an enviably high standard of living, analysis sponsored by the United Nations suggests that this has come at the expense of the degradation of the natural environment. Fortunately, over the last 20 years Australian industry has been shifting to a more resource efficient, low carbon economy. However, the pace of change is considerably slower and on a smaller scale than many other OECD nations.

Structural adjustment and innovation by industry towards reducing its environmental footprint (so called eco-innovation) is a necessary and critical aspect of a green growth transition and will help drive Australia towards a more diverse, resilient and prosperous future. A snapshot of eco-innovation in Australia shows that only 10% of Australian businesses are eco-innovators and that only 5% of Australian businesses eco-innovate in a strategic way. Australian businesses rank poorly on an international scale. European countries' levels of eco-innovation range between 10 to 75%. More businesses need to be encouraged to reduce their environmental footprint through innovation.

Businesses that identify as strategic eco-innovators generally outperform other innovators on a range of investment and performance criteria. Strategic eco-innovators show all the hallmarks of a high-performing business. They are more collaborative, more innovative and more productive. Compared with innovative businesses that don't pursue environmental benefits, strategic eco-innovators are:

- 30% more likely to increase productivity over the previous year.
- 40% more likely to increase the number of export markets targeted.
- 68% more likely to increase training for employees.
- 41% more likely to increase social contributions.

Public investment in environmental R&D is high by international standards and evidence suggests that the quality of the research is high. Australia's environmental patenting is improving and it has a high technological advantage in environmental technologies. Given the multidisciplinary nature of eco-innovation, more businesses need to invest in innovation and collaboration with public research institutions to take advantage of new or maturing markets for environmental goods and services.

There is evidence of recent acceleration of investment in eco-innovation both internationally and domestically. Australian industry spent \$401 million in R&D for environmentally sustainable economic development in 2010–11 and levels of investment are growing faster than most other areas of R&D. Some precursor innovation investments such as in environmental R&D can have a lag effect, such that this increasing investment may lead to an increase in the rate of Australian eco-innovation in subsequent years.



INTRODUCTION

The objective and structure of this report

The Australian Innovation System report demonstrates the importance of innovation and monitors the performance of Australia's innovation system at the national level. 'Performance' is measured by comparing Australia with the performance of other countries around the world. This report is the fourth in the series and builds on the data and insights from previous reports and explores different or new facets of the innovation system.

Using the most recent available data, this report examines the existing level of integration of the Australian economy with the rest of Asia (Chapter 1). It then uses this as a context to analyse the characteristics of high performing innovation systems in the world, in addition to the Australian innovation system's capacity to capitalise on the opportunities coming out of Asia in the coming years (Chapter 2). The report examines macro-economic stability and flexibility to respond to opportunities and support the capability of Australia's workforce and institutions to innovate and expand (Chapter 2). It analyses trends in skills and employment as they relate to innovation (Chapter 3), and research capacity (Chapter 4). Finally, the report examines the vital role of entrepreneurship and business innovation in boosting 'green growth', exploring how eco-innovation in Australia can improve the sustainable management of natural resources and transform industries to deliver a cleaner future (Chapter 5).

The report presents commentary on the measurement or performance of the innovation system from a range of experts in the form of feature articles. Case studies throughout the report also highlight recent achievements and actions by individuals and organisations in the national innovation system. For a complete picture of government innovation initiatives the reader is encouraged to visit www.innovation.gov.au, www.business.gov.au, www.usindustry.gov.au, www.arc.gov.au, www.climatechange.gov.au, www.grantslink.gov.au or www.skillsconnect.gov.au websites.

What is innovation?

Innovation has many dimensions—such as the type and scale of innovation—that make defining it a complex issue.² It is necessary, however, to adopt an internationally recognised definition of innovation if we are to compare Australia with other countries.

*Innovation is the implementation of a new or significantly improved product (good or service), process, new marketing method or a new organisational method in business practices, workplace organisation or external relations.*³

Innovation is fundamentally about market experimentation by business, involving the acceptance or, at least, tolerance of the risk of failure. This acceptance is enabled by recognising that learning will come from these mistakes. Innovation activities include more than just R&D, relying heavily on execution or implementation: bringing an idea to a market or another material outcome that generates an impact on the economy, society, and/or environment. In 2010–11 Australian businesses spent approximately \$29 billion on innovation. The most common expenditure categories were acquisition of machinery, equipment or technology and training, which was approximately three times more common than in-house R&D.⁴

2 See further discussion in Australian Government (2011) *Australian Innovation System Report—2011*, DIISR, Canberra, p.7.

3 OECD (2005) *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, 3rd edition, OECD and European Commission.

4 Australian Bureau of Statistics (ABS) (2012) *Innovation in Australian Business, 2010–11*, data cube: Types of Expenditure for Innovation, cat. no. 8158.0, [Accessed 20 June 2013].

What is an innovation system?

At its most basic level, an innovation system is about networks of people. It is about the organisations, rules, cultures and interactions these people create, and how these elements are used to generate and exploit knowledge and ideas. All of these aspects of an innovation system evolve over time to give it unique characteristics. Innovation systems are a product of history; they are path dependent and embedded in a country's industrial structure and institutions. Yet innovation systems can change and, in some cases, change dramatically in just a few decades. This report adopts the following definition:

An innovation system is an open network of organisations both interacting with each other and operating within framework conditions that regulate their activities and interactions. These three components of the innovation system: networks; innovation activities; and framework conditions, collectively function to produce and diffuse innovations that have, in aggregate, economic, social and/or environmental value.⁵

Innovation systems are important because a well-functioning innovation system is fundamental to the long-term sustainability of the country and to maintaining and growing our standard of living. This means achieving economic dividends, prosperity and positive social and environmental outcomes. To achieve the above will require a lift in productivity. This is because the principal factor contributing to long-term income growth and, consequently, to material standards of living is productivity.⁶ Innovation is, in turn, a key driver of productivity growth.⁷

Measuring and comparing national innovation systems

A high performing national innovation system is a co-requisite for both capitalising on the opportunities and withstanding the challenges of the rapid maturation of Asian economies.

The Australian innovation system generates only 3% of world knowledge, so the economy relies on innovations generated elsewhere. The majority of Australian firms are modifiers and adopters of innovation and technology. It is therefore important to understand how our innovation system fits with other innovation systems in countries of the Asian region, which are demanding high levels of novelty in innovation.

Defining, measuring and comparing innovation systems present conceptual challenges. There is not an innovation system prescriptive theory that identifies clear boundaries of an innovation system. In addition, innovation systems literature strongly emphasises that there is not an optimal innovation system.⁸ For the concept of an innovation system to be useful for policy development, it is therefore necessary to transition it from the conceptual to the operational stage. Generally, a mix of quantitative (indicator based) and qualitative (national case studies) methods are used in the literature in an attempt to adequately capture the system and its workings. This report attempts to review this.

The idea of high performing innovation systems should also be seen in the context of policy learning and experimentation. The key questions are about understanding what can or cannot work given the myriad of actors, links and framework conditions in the innovation system. Identifying high performing national innovation systems provides a reference point to start a focused investigation into the areas of strength of each country for the purposes of policy development.

One possible approach is outlined in the feature article below by one of the world leading innovation system experts.

5 *Framework conditions*, also known as institutions or rules of the game, comprise a set of established practices, rules or laws that regulate the interactions between individuals and organisations.

6 Australian Government (2012) *Australian Innovation System Report—2012*, Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE), Canberra.

7 Australian Government (2013) *Demystifying productivity growth: a foundation for policy debate*, DIISRTE, Canberra.

8 Edquist C (2008) *Design of Innovation Policy through diagnostic Analysis: Identification of Systemic Problems (or Failures)*, CIRCLE Electronic Working Paper Series, 2008/06, Lund University, Lund, Sweden.

FEATURE: COMPARING NATIONAL INNOVATION SYSTEMS FOR INNOVATION POLICY PURPOSES

By Charles Edquist, CIRCLE Lund University, Sweden

This short feature focuses upon the identification of problems in innovation systems through diagnostic analyses, i.e. how innovation systems should be analysed with the design of innovation policy in mind. In order to be able to identify “policy problems”, more precisely problems that should be subject to innovation policy intervention, we must know in what respects innovation systems are performing well or badly. We must measure the performance of an innovation system, which can be done by estimating the innovation intensities for different categories of innovations.

To be useful for policy purposes, the measurements and descriptions of different systems must be comparable. The reason for this is that it is not possible to say whether an innovation intensity is high or low in a certain system if there is no comparison with innovation intensities in other systems. Hence, we cannot identify ‘optimal or ideal’ innovation intensities (just as we cannot specify an optimal innovation system) either. We simply cannot determine how much innovation of different kinds that is the ‘optimal’ quantity of innovations.

This means that problems cannot be identified through theoretical analysis alone. The problems cannot be identified through a comparison between an empirically existing system of innovation and an optimal one – since we are unable to specify an optimal system of innovation. What remains is then to compare existing systems of innovation with each other. Such comparisons can be made of the same system over time, or between different systems.⁹ Only in this way can we identify the “policy problems”. In other words, ‘Policy problems’ can be identified only by comparing existing innovation systems with each other – over time and space.

The rationale of innovation policy is to solve or mitigate policy problems. If the system is performing very well, thanks to its spontaneous operation (based on the actions performed by private organisations), then no problem exists and policy intervention is not needed. Such intervention is only called for when the system is performing badly – in a relative sense. Put differently, a ‘problem’ exists only if the (politically formulated) objectives in terms of innovation intensities are not achieved by private organisations.

Innovation policy objectives should be formulated in terms of intensities of various kinds of innovations. When doing so, it is important to know the consequences of various categories of innovations, because there is a difference between innovations as such and the consequences of innovations for economic growth, the environment, military strength, etc.

However, an identification of a ‘problem’ by means of empirical-comparative analysis is not sufficient as a basis for designing innovation policies; it is only a first step. First of all, the existence of a problem is only a necessary condition for pursuing an innovation policy. Public organisations must also have the ability to solve or mitigate the problem. An analysis of the causes of the problems might be necessary and new organisations and institutions might have to be created in order to develop this ability. Knowing that there is reason to consider public intervention is not enough. An identification of a problem only indicates where and when intervention is called for; it says nothing about how it should be pursued. In order to be able to design appropriate innovation policy instruments, it is necessary to also know the causes behind the problem identified – at least the most important ones. A causal analysis might also reveal that public intervention is unlikely to solve the problem identified, due, for example, to the lack of ability.

⁹ It is also possible to compare an existing system with a ‘target system’. Such a system can be specified. However, it can never be argued that it is an optimal or ideal one.





Systematic identification of such determinants of innovation processes is a surprisingly under-researched area in innovation studies. Partly for this reason, but also because of the very complex nature of innovation processes, as well as the difficulty of developing causal explanations in the social sciences, it is very difficult to arrive at a 'complete' causal explanation of the propensity to innovate in a system of innovation. We might have to accept being able to point out only the main activities behind a low propensity to innovate. For a hypothetical list of activities in innovation systems, see Box 1.

The combination of a problem-identifying analysis and a causal explanation may be called a 'diagnostic analysis'. Such an analysis may provide a basis for an efficient therapy or treatment – namely, an innovation policy. Without a diagnosis it is impossible to know what prescription is required, and without timely prescriptions there is a risk that we might become pathologists – that is, try to find the diagnosis after the patient has passed away. Indeed, satisfactory causal explanations in the social sciences are rare phenomena. Therefore, an inability to explain in detail might not be a reason to abstain completely from intervention in the process of innovation. Because problems identified may sometimes be very severe – for the economy, for the environment, or for the social conditions – trial-and-error intervention may be necessary. However, it is still necessary to have some clues about the most important causes of a problem.

Let me summarize in telegraphic form what has been argued in this paper with regard to the design of innovation policy.

1. A diagnostic analysis is firstly related to the performance of an innovation system. We must be able to point out the kind of innovation that is performing badly in the system. This is defined as a problem. What is also required is that the objectives of the innovation policy are specified in terms of the kinds of innovations that should be influenced, i.e. the policy objectives should be expressed in terms of innovation intensities.
2. However, a diagnostic analysis also includes an identification of the causes of the problems identified. We have proposed that such an analysis may be carried out in terms of ten activities in systems of innovation (Edquist 2011) – see Box 1.

In carrying out a causal analysis to provide a basis for innovation policy, there are two important analytical questions (questions 1 and 3 below), and two policy questions (questions 2 and 4):

1. What is the division of labour in activities influencing (a low) performance with regard to certain categories of innovation? (Where is the border line between the respective parts of a certain activity performed by private and public organisations?)
2. What should the division of labour be? Should there be more/less public intervention, i.e. should the border line between the respective parts of each activity performed by the private and public organisations be moved?
3. What are the characteristics of the activities performed by public organisations (i.e. what are the characteristics or features of the public intervention)?
4. How should the characteristics of the public intervention be changed?





Box 1: Key activities in systems of innovation

I. Provision of knowledge inputs to the innovation process

1. Provision of R&D results and, thus, creation of new knowledge, primarily in engineering, medicine and natural sciences.
2. Competence building, e.g. through individual learning (educating and training the labour force for innovation and R&D activities) and organisational learning. This includes formal learning as well as informal learning.

II. Demand-side activities

3. Formation of new product markets.
4. Articulation of new product quality requirements emanating from the demand side.

III. Provision of constituents for systems of innovation

5. Creating and changing organisations needed for developing new fields of innovation. Examples include enhancing entrepreneurship to create new firms and intrapreneurship to diversify existing firms; and creating new research organisations, policy agencies, etc.
6. Networking through markets and other mechanisms, including interactive learning among different organisations (potentially) involved in the innovation processes. This implies integrating new knowledge elements developed in different spheres of the system of innovation and coming from outside with elements already available in the innovating firms.
7. Creating and changing institutions – e.g., patent laws, tax laws, environment and safety regulations, R&D investment routines, cultural norms, etc. – that influence innovating organisations and innovation processes by providing incentives for and removing obstacles to innovation.

IV. Support services for innovating firms

8. Incubation activities such as providing access to facilities and administrative support for innovating efforts.
9. Financing of innovation processes and other activities that may facilitate commercialisation of knowledge and its adoption.
10. Provision of consultancy services relevant for innovation processes, e.g., technology transfer, commercial information, and legal advice.

For more information visit www.charlesedquist.com¹⁰

¹⁰ Adapted from Edquist (2011). *Note:* For a more detailed analysis of how to analyse innovation systems for policy purposes, see: Edquist, C (2011) *Design of innovation policy through diagnostic analysis: Identification of systemic problems (or failures) in Industrial and Corporate Change* 20 (6), 1 – 29., doi: 10.1093/icc/dtr060. For a comparison of ten national systems of innovations in Asia and Europe, see: Edquist, C. and Hommen, L. (ed.) *Small Country Innovation Systems: Globalisation, Change and Policy in Asia and Europe*, Edward Elgar Publishing, 2008 (published in paperback 2009), p.544. (Also published in Chinese by Science Press [Beijing] in 2012).

Why should we innovate?

Innovation is synonymous with change and a high capacity to deal with change allows the nation to be resilient and prosper. Australia therefore needs a resilient innovation system that coordinates and shapes itself to address immediate or future challenges and opportunities.¹¹ To create a high performing innovation system Australia needs to engender a culture of creativity, innovation and resilience in all participants.¹² From an extensive body of literature on the subject, innovation is considered a proactive tool for dealing with change for any individual or organisation. Of the senior executives surveyed by the General Electric (GE) Global innovation barometer, 92% agree that innovation is the main lever to create a more competitive economy and 84% believed that 21st Century innovations will be those that bring value to society as a whole, not only to individual consumers or citizens.¹³ Ninety one per cent of Australian businesses report a benefit from innovation and this can be as high as 97.6% for large Australian businesses. These benefits include increased revenue, reduction in costs, gaining a competitive advantage and improved customer service¹⁴ (the benefits of innovation to business and society are further detailed in subsequent chapters).

Innovation is not an end in itself but rather a tool that can be used to achieve broader social, economic or environmental outcomes. As such, it is useful to analyse these high level outcomes (Table 1.1). Australia's GDP per capita and GDP per hour worked are indicators of economic prosperity and productivity. In these measures Australia is closing the gap with leading developed countries in the OECD. The 2011 OECD data indicates that Australia's gap with the top five OECD countries is only 22% and 29% in these two indicators respectively. Australia's competitive position, reflected by the Global Competitiveness Index, is high in the world context (20th out of 144 countries) but moderate in the OECD (15th out of 34). However, the gap with the top five OECD countries is small as Australia has considerable strengths in some of the factors that make up this index, including the development of financial markets. Australia has maintained a high ranking in the Human Development Index – only behind Norway. Australia's ranking in environmental performance continues to be one of the worst in the developed world (see Chapter 5 for further discussion of the Environmental Performance Index). Australia's resilience to economic cycles was ranked very high during the last decade; however, its position deteriorated dramatically in 2013 and the ranking changed from 5th to 19th. The International Institute for Management Development (IMD) source report does not explain why Australia's score has dropped. It may be due to the perception of Australia's strong dependence on China's demand for our coal and iron ore, and the concerns that the mining boom may have finished as China transitions away from heavy industrialisation. Domestically, the retail sector has remained weak and the high Australian dollar continues to erode the competitiveness of Australian export-oriented industries.

11 For a broader discussion of the innovation system refer to the *Australian Innovation System Report—2011*, DIISR, pp.11–29.

12 The concept of business innovation culture is further explored in Chapter 3 of the *Australian Innovation System Report—2012*, DIISR, p.30.

13 GE [2012] *Global Innovation Barometer: Australia, 2012 Report*, GE Australia & New Zealand, Melbourne.

14 ABS [2012] *Innovation in Australian Business, 2010–11*, cat. no. 8158.0.

Table I.1 Outcome indicators of innovation

Indicators	Australian trend data ⁽ⁱ⁾						OECD comparison				
	2000	2005	2010	2011	2012	2013	Australia's score ⁽ⁱⁱ⁾	OECD average ⁽ⁱⁱⁱ⁾	OECD top 5 average ^(iv)	Gap from the top 5 OECD performers (%) ^(v)	Ranking against OECD countries ^(vi)
GDP per capita relative to the USA (USA = 100) ¹	80	82	87	87	92	-	86.56	70.57	110.45	21.6	7th
GDP per hour worked (USA = 100) ¹	79	82	87	87	88	-	87.43	72.2	122.3	28.5	9th
Global Competitiveness Index ²	-	-	16th	20th	20th	-	5.12	4.93	5.55	7.7	15th
Human Development Index ³	2nd	2nd	2nd	2nd	2nd	-	0.94	0.88	0.93	No gap	2nd
Environmental Performance Index ⁴	30th	42nd	48th	-	48th	-	56.61	62.33	70.75	20.0	28th
Resilience of the Economy to economic cycles ^{5, (a)}	-	1st	2nd	2nd	5th	19th	6.51	5.37	7.4	12.0	12th

Source: [1] OECD Stats Database, May 2011. [2] World Economic Forum (WEF), *The Global Competitiveness Report 2012-2013*. [3] The United Nation Development Program, *Human Development Report 2012*. [4] Yale University and Columbia University, in collaboration with the World Economic Forum at the Joint Research Centre of the European Commission, *Environmental Performance Index 2012*. [5] Institute for Management Development (IMD), *World Competitiveness Online 1995-2013, May 2013*.

Indicator notes: (a) For this indicator, survey respondents were asked to answer the question "Resilience of the economy to economic cycles" scores refer to a (weak) 0 – 10 (strong) scale.

Table notes: (i) Data is presented in calendar year format. Where the data is in financial years, it is expressed in terms of the year where the financial year begins e.g. 2010-11 is shown as 2010. (ii) The 'Australia's score' field presents the Australian values used in the OECD comparisons. (iii) This is the arithmetic (simple) average of the OECD country scores. (iv) This is the arithmetic (simple) average of the top five OECD countries in a ranked list. (v) This represents Australia's distance from the frontier as defined by the average of the top five ranked OECD countries. It is calculated as $100 * (\text{Top five average} - \text{Australia's score}) / \text{Top 5 average}$. Where the solution is a negative value or zero, "no gap" is shown in the cell. (vi) OECD rankings are performed on those OECD countries for which data is available. Individual data availability may vary between indicators. "-" = data not available.

Table I.2 Innovation performance: components of rankings and Australia's comparison¹⁵

Ranking System	OECD Comparison				
	Australia's score	OECD average	OECD top 5 average	Gap from the top 5 OECD performers ^(e)	Ranking against OECD countries
Global Innovation Index Framework ^{1, (a)}	51.91	52.07	63.32	18	20
The Atlantic Century II ^{2, (b)}	146.28	118.14	166.98	12	7
WEF Global Competitiveness Report ^{3, (c)}	4.51	4.51	5.64	20	20
IMD World Competitiveness Online ^{4, (d)}	63.22	63.71	75.98	17	18

Source: [1] INSEAD and WIPO, *The Global Innovation Index 2012: Stronger Linkages for Global Growth*. [2] ITIF, *The Atlantic Century II – Benchmarking EU & U.S. Innovation and Competitiveness July 2011*. [3] World Economic Forum (WEF), *The Global Competitiveness Report 2012-2013*. [4] Institute for Management Development (IMD), *World Competitiveness Online 1995-2013, May 2013*.

Indicator notes: (a) Measure used: Global Innovation Index. Overall comparison includes 141 countries. (b) Measure used: Human capital, Innovation Capacity, Entrepreneurship, Information Technology (IT) Infrastructure pillars. Overall comparison includes 44 countries. OECD comparison does not include Iceland, Israel, Luxembourg, New Zealand, Norway or Switzerland as these countries were not included in the dataset (c) Measure used: Innovation pillar. Overall comparison includes 142 countries. (d) Measure used: Technological Infrastructure and Scientific Infrastructure pillars. Overall comparison includes 60 countries. (e) Gap between the average score of top 5 and Australia's score.

¹⁵ These are a combination of input and output metrics.

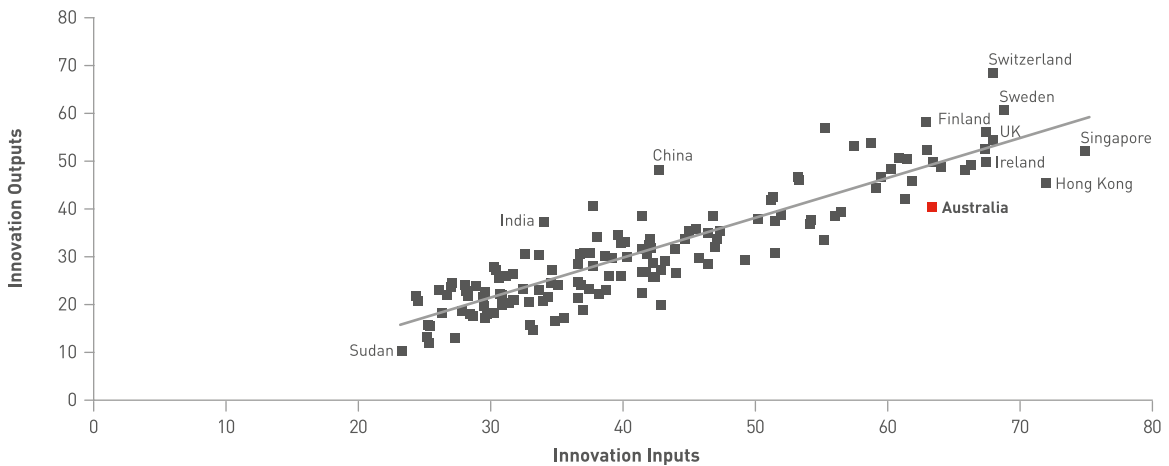
Table I.3 Overall leaders in each ranking

Rank	The Global Innovation Index Framework ^{1, (a)}	The Atlantic Century II ^{2, (b)}	WEF Global Competitiveness Report ^{3, (c)}	IMD World Competitiveness Online ^{4, (d)}
1	Switzerland	Finland	Switzerland	United States
2	Sweden	Singapore	Finland	Israel
3	Singapore	Denmark	Israel	Japan
4	Finland	United Kingdom	Sweden	Sweden
5	United Kingdom	Sweden	Japan	Germany
6	Netherlands	Canada	United States	Switzerland
7	Denmark	South Korea	Germany	Korea
8	Hong Kong (China)	Australia	Singapore	Taiwan
9	Ireland	Belgium	Netherlands	Singapore
10	United States	United States	United Kingdom	Denmark

Source: [1] INSEAD and WIPO, The Global Innovation Index 2012: Stronger Linkages for Global Growth. [2] ITIF, The Atlantic Century II – Benchmarking EU & U.S. Innovation and Competitiveness July 2011. [3] World Economic Forum (WEF), The Global Competitiveness Report 2012-2013. [4] Institute for Management Development (IMD), World Competitiveness Online 1995-2013, May 2013.

Indicator notes: (a) Measure used: Global Innovation Index. Overall comparison includes 141 countries. (b) Measure used: Human capital, Innovation Capacity, Entrepreneurship, Information Technology (IT) Infrastructure pillars. Overall comparison includes 44 countries. OECD comparison does not include Iceland, Israel, Luxembourg, New Zealand, Norway or Switzerland as these countries were not included in the dataset (c) Measure used: Innovation pillar. Overall comparison includes 142 countries. (d) Measure used: Technological Infrastructure and Scientific Infrastructure pillars. Overall comparison includes 60 countries. (e) Gap between the average score of top 5 and Australia's score.

Chart I.1 Innovation inputs versus outputs



Source: INSEAD and WIPO, The Global Innovation Index 2012: Stronger Linkages for Global Growth.

Note: Measures used: Global Innovation Outputs Sub-Index and Global Innovation Inputs Sub-Index. Overall comparison includes 141 countries.

Innovation and the growth of Asia

Every chapter in this report includes data, analysis, features and case studies that focus on how facets of Australia's innovation system are integrated with its Asian counterparts.

In the past, Australia has benchmarked the performance of its national innovation system against the countries of the OECD – overwhelmingly the major centres of science and innovation, industrial output and global capital in Europe and North America. While these traditional hubs will continue to be important for decades to come, the international economic order (and hence the gravity of innovation output) is shifting rapidly towards the mass urban and financial hubs of the Asian region, where the tyranny of distance is less of a concern for Australia.¹⁶

The number of middle class consumers in Asia is projected to increase sixfold to 3.2 billion from 2009 to 2030 alone.¹⁷ This highlights the importance of Asia not only as a market for Australia's goods and service exports, but also as a destination for other areas of endeavour that are linked to the national innovation system, such as science and education. Rising affluence that facilitates travel and the explosion in social media and mobile telecommunication are spurring much greater interaction between Asian countries in industry, commerce and culture.

The economic role of Asia in the global economy is reaching critical mass. The trend of growth and dynamism in Australia's immediate region with its huge, relatively young and globally connected population is a reality that should now inform innovation policy in Australia.

Australian businesses will only be able to capitalise on growth opportunities in this region if they are innovative and versatile. In macroeconomic terms, Australia has been one of the most successful countries in taking advantage of trade with an industrialising Asia. However, our first mover advantages in iron ore and thermal coal will not last forever. As China and other Asian countries continue their economic development, demand for more specialised products and services will emerge (see also Chapter 5). Australia must be in a position to provide high value-added products and services for these emerging markets.

Australia will be an attractive destination for investment from the world's fastest growing and most dynamic region, Asia, if it becomes a world leader in innovation. This means Australia needs a well-functioning innovation system that can perform three key functions: effectively connect networks and organisations; generate and exploit knowledge and innovation; and create economic and business conditions that encourage investment in innovation. Framework and business conditions are the regulations and cultures that can influence the rate and extent of innovation. A high performing innovation system should be resilient and able to adapt to change.

Global Value Chains

Global Value Chains (GVCs) are a useful way to conceptualise international production, trade and investment in a systematic way. This model is used to discuss Australia's trade engagement with Asia. GVCs, based on Michael Porter's model of value chains, are a way to analyse and identify specific activities¹⁸ in which firms can create value and competitive advantage.¹⁹ GVCs are value chains that are dispersed globally, meaning that different stages of the value chain (e.g. design, production, marketing, distribution) are located in different countries.²⁰ In a global value chain, value is added in different stages as each country specialises in particular tasks along the supply chain.

The concept of GVCs helped to shift the understanding away from just manufacturing to innovation through adding value across the entire chain. Higher value can be added through components of the value chain, such as design, R&D, commercialisation, logistics, marketing and branding, in addition to manufacturing and assembly.²¹ This model is consistent with the process of structural changes that have occurred in most developed economies where the service sector has taken a higher share of the economy, while manufacturing and other sectors have shrunk. Firms have increasingly incorporated services into manufacturing activities as a way to increase the value to customers (see Chapter 1).

16 *Ibid.*, p.73.

17 *Ibid.*, p.63. Note: 'Middle class' is defined as those households with daily expenditures of between US\$10 and US\$100 per person.

18 These activities include primary activities: inbound logistics; operations, outbound logistics, marketing and sales; and services and support activities such as procurement, technology development, human resources management and firm infrastructure.

19 Porter, ME (1985) *Competitive Advantage*, Free Press, New York.

20 OECD (2012) *Australian Manufacturing in the Global Economy*, Paper Commissioned by DIISRTE, OECD Publishing, p.21.

21 World Economic Forum (2012) *The Shifting Geography of Global Value Chains: Implications for Developing Countries and Trade Policy*, World Economic Forum, Geneva, p.21.

Australian firms can break into GVCs by providing niche services with a high value-added component, as well as parts and components. In many developed economies, over half of value added is associated with service activities like transportation, logistics, finance, insurance and communications.²² Australia can therefore move up the value chain not just by moving into high-value sectors, but also by engaging in high-value activities like R&D, design, marketing and legal services within various sectors. This suggests that policy should not only focus on assisting firms to engage with new value chains, but also to better engage and position themselves within existing value chains.

A note on methodology

Where possible, this report's concepts, definitions and methodology are based on the Australian Government's *Innovation Metrics Framework Report* and the concept of an innovation system introduced in previous reports.²³ A key challenge to describing the innovation system is the timeliness and quality of quantitative data. This report, although released in 2013, paints a picture of where we were at two to five years ago. For this reason it is important to capture more qualitative information on innovation through case studies and features. Data in this report is current as of July 2013. The report contains robust and rigorously collected indicators produced by the Australian Bureau of Statistics (ABS) that are often internationally comparable. This report also includes a range of less rigorous business opinion survey information in support of official data. This survey information is more current, but tends to feature very limited numbers of survey participants. Using these indicators helps to give a more current snapshot of business conditions or sentiment. This report uses a variety of indicators drawn from different datasets, each of which uses its own methodologies. It is important to recognise that each indicator used has its own methodological limitations. It is not possible to provide an analysis of the pros and cons of each methodology within this report. It is therefore recommended that the reader refer to the source for metadata and more comprehensive discussion of methodological limitations.

Where possible all table indicators are provided back to 1995. Most Australian innovation data is compiled according to fiscal years, while OECD data is compiled according to calendar years.

As part of a systems approach to measuring innovation, international comparisons for each indicator are presented where possible. Unlike Australia, many other OECD countries' national survey instruments for measuring business innovation are not mandatory, leading to variable coverage and low response rates.²⁴ These differences may have the effect of skewing other country data towards the most innovative businesses that are motivated to report their innovative activities. In addition most OECD countries collect three-year aggregates of business activity, while Australia reports annually. The likely consequence is that Australia's innovation performance will appear lower compared with other OECD countries, although analysis by the Australian Bureau of Statistics suggests this is not a significant effect. Other measures of education and R&D investment are more comparable. Comparing Australia with other countries is not about competition across borders. Australian innovations such as the Commonwealth Scientific and Industrial Research Organisation's (CSIRO) WLAN²⁵ are making the world, not just Australia, a better place. Country comparisons are made because policy mixes can be quite different. Each country is like an experiment for the global innovation system. So country comparisons help us think about which activities work best in different frameworks and how networks and cultures interact to make the world a better place.

22 OECD (2013) *Drawing the Benefits of Global Value Chains*. OECD Publishing, p.13.

23 See further discussion in Australian Government (2011) *Australian Innovation System Report – 2011*, DIISR, Canberra, pp.11–13.

24 OECD (2009) *Innovation in Firms: A Microeconomic Perspective*, OECD Publishing.

25 CSIRO (2013) Wireless LANs, <http://www.csiro.au/science/wireless-LANs> [Accessed 19 June 2013].

CHAPTER 1: GLOBAL COMPETITIVENESS, INNOVATION AND INTEGRATION WITH ASIA

Introduction

The growth of Asian economies presents many opportunities for Australia, but harnessing these opportunities is not something that can be taken for granted. Australia's beneficial proximity to the rest of Asia needs to be complemented with competitive advantages and specialisation in innovation. International engagement and innovation are closely linked. Evidence suggests that business engaged in international markets tend to have improved innovation performance.²⁶ Innovation is also a key vehicle to international markets. The 2012 Australian Innovation System Report showed that Australian businesses that innovate are three times more likely to export and 18 times more likely to increase the number of export markets targeted than those that do not innovate.²⁷ But it is not just a matter of individual businesses. A well-functioning national innovation system should sustain the creativity, resourcing and motivation of entrepreneurs to seize the opportunities of the emerging Asian markets through innovation.

This chapter looks at the present levels of Australian international engagement, with a particular focus on Asia and innovation. Engagement has many dimensions: trade in goods and services; cross-border investment patterns; joint research and development; trade in intellectual property; the flow of people and skills; and foreign development aid.

Australia's international engagement

Table 1.1 shows different indexes of Australian connectivity and engagement with the world that are discussed across the chapter. The DHL Global connectedness index²⁸ indicates that Australia (score of 60) has marginally improved its global engagement since 1995 and is slightly behind the OECD average (score 64). A considerable gap still exists between Australia and the top five OECD countries (score 82) in terms of national connectedness. In general, top countries are relatively small and serve as regional or continental hubs, for example Singapore in Asia and the Netherlands in Europe. Canada and Australia, two countries comparable in size and economic structure, rank similarly at 20th and 21st positions among the OECD. Of the four pillars that make up the index—trade, investment, information and people—Australia ranks high on information, but low on trade.

Two measures of R&D international engagement shown in Table 1.1 are the proportion of Gross Expenditure on R&D (GERD) and Business Expenditure on R&D (BERD) financed from abroad. Australia's ratio in both indicators has fallen significantly since the year 2000, driven by rapid growth in domestic GERD and BERD over the same period. Australia ranks low in the OECD in these measures, 23rd and 20th respectively. Absolute values of GERD and BERD financed from abroad, however, increased over the decade until 2006–07 reaching a maximum value of \$518 million and \$241 million respectively. In 2008–09, the last year that the ABS published this figure, GERD financed from abroad dropped to \$476 million and BERD financed from abroad fell to \$189 million.

26 Elko J, Kleinschmidt EJ & Cooper RG (1988) The Performance Impact of an International Orientation on Product Innovation, *European Journal of Marketing*, 22(10), 56–71; Pla-Barber J & Alegre J (2007) Analyzing the Link between Export Intensity, Innovation and Firm Size in a Science-Based Industry, *International Business Review*, 16(3), 275–293; Bloom N, Dorgan S, Dowdy J & van Reenen J (2007) Management Practice and Productivity: Why They Matter, *Management Matters* July 2007, Centre for Economic Performance and McKinsey & Company, London.

27 Australian Government (2012) *Australian Innovation System Report—2012*, DIISRTE, Canberra, p.6.

28 Ghemawat P & Altman SA (2012) *DHL Global Connectedness Index 2012*, IESE Business School, Barcelona Spain.

Table 1.1 Main Indicators of Australia's International Engagement

Indicators	Australian trend data ⁽ⁱ⁾											OECD comparison			
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	Australia's score ⁽ⁱⁱ⁾	OECD average ⁽ⁱⁱⁱ⁾	OECD top 5 average ^(iv)	Gap from the top 5 OECD performers ^(v)	Ranking against OECD countries ^(vi)
DHL Global connectedness Index ^{1, (a)}	-	-	57	58	59	60	61	60	60	-	60	64	82	26	21st
Trade as % of GDP ²	38	41	39	41	41	42	45	40	41	43	41	104	209	80	30th
Exports in goods as % GDP ^{3, (b)}	13.6	15.6	14.0	15.3	14.5	17.7	15.3	16.5	17.8	16.2	16.2	37.7	75.5	79	31st
Exports in services as % of GDP ^{3, (b)}	4.6	4.7	4.0	4.0	4.1	4.5	4.1	4.0	4.0	4.1	4.1	12.0	36.5	89	30th
Exports in raw commodities as % of the GDP ^{3, (c)}	-	-	-	-	5.9	9.6	8.1	9.7	10.0	9.6	9.6	3.8	10.1	5	3rd
Net Foreign Direct Investment inflows as a % of GDP ³	3.3	3.3	-3.5	4.2	5.3	4.3	3.0	3.0	4.9	-	4.9	3.9	14.5	66	8th
Foreign Direct Investment as a source of technology transfer ^{4, (d)}	-	-	-	5.2	5.4	5.5	5.4	5.2	5.1	5.0	5.0	4.9	5.6	11	15th
Business impact of rules on foreign direct investment (FDI) ^{4, (e)}	-	-	-	5.4	5.3	5.3	5.1	4.9	4.9	5.0	5.0	4.8	5.7	13	15th
Technology balance of payments - (receipts minus payments as a % of GDP) ⁵	-0.048	-0.167	-0.096	-0.028	-0.136	-0.200	-0.188	-0.216	-0.232	-	-0.232	0.246	1.244	119	20th
Intellectual property balance of payments (\$ millions) ⁶	-	-1,357	-1,325	-1,587	-1,631	-1,665	-1,860	-2,029	-2,517	-2,717	-	-	-	-	-
Percentage of Australian businesses with international collaboration on innovation ⁷	-	-	-	3.6	-	2.4	-	4.0	-	-	2.4	18.5	31.0	92	25th
Proportion of GERD financed abroad % ⁵	1.9	3.5	2.9	2.4	-	1.6	-	-	-	-	1.6	8.0	18.5	91	23rd
Proportion of BERD financed abroad % ⁵	3.0	4.7	1.6	1.9	1.2	1.0	1.0	0.9	-	-	0.9	9.7	25.7	96	20th
R&D expenditure of foreign affiliates as a % of R&D expenditure of the enterprise ⁸	31.1	-	-	36.5	36.5	35.5	32.1	29.3	-	-	-	-	-	-	-
Net gains of skilled people through migration ^{9, (f)}	-	-	41.9	58.2	69.8	80.2	74.0	47.3	50.2	73.9	-	-	-	-	-
Proportion of patents with foreign co-inventors ³	-	13.2	15.2	16.7	16.0	15.8	17.0	18.0	-	-	18.0	24.2	43.6	59	24th
Short term business trips churn ('000) ^{10, (g)}	814	1079	1286	1385	1461	1445	1309	1461	1522	-	-	-	-	-	-
Short term Education trips churn ('000) ^{10, (g)}	180	298	434	459	508	560	620	617	607	-	-	-	-	-	-
Short term convention and conferences trips churn ('000) ^{10, (g)}	190	291	367	365	395	406	329	394	403	-	-	-	-	-	-
Short term employment trip churn ('000) ^{10, (g)}	126	191	288	353	384	418	397	411	444	-	-	-	-	-	-

Sources: [1] DHL Global Connectedness Index 2012, Deutsche Post. [2] World Development Indicators & Global Development Finance, The World Bank, 2012 [3] OECD Factbook Statistics (OECD.Stat). [4] World Economic Forum, The Global Competitiveness Report 2012-2013. [5] OECD, Main Science and Technology Indicators database, 2013/1. [6] ABS (2012) *International Trade in Services by Country, by State and by Detailed Services Category*, cat. no. 5368.0.55.004. [7] OECD Measuring Innovation: A new perspective 2010; OECD, Science, Technology and Industry Scoreboard 2011; Australian Bureau of Statistics, *Innovation in Australian Business* (special data request) [8] ABS (2011) Research and Experimental Development, Businesses, Australia, 2009-10 cat. no. 8104.0. [9] Department of Immigration and Citizenship (2013) Skilled Migration as proportion of net overseas migration (NOM), special data request [10]. ABS (2013) Overseas Arrivals and Departures data, special data request.

Indicator notes: (a) DHL Global connectedness Index is calculated based on four pillars: trade, capital, information and people. (b) The figures are derived by DIICCSRTE from the OECD source based on data on exports in goods and services and GDP in billion US dollars, current prices and PPPs. (c) Exports are measured in current US\$ and classified according to the Harmonised Commodity Description and Coding System (HS) 2007. The GDP used to derive the indicator is measured in US\$, current prices, current exchange rates. The HS 2007 chapters selected as a proxy for raw commodities comprise: 01: Live animals; animal products; 10: Cereals; 26: Ores, slag and ash; 27: Mineral fuels, mineral oils and products of their distillation; bituminous substances; mineral waxes. (d) For this indicator, survey respondents were asked to answer the question "To what extent does foreign direct investment (FDI) bring new technology into your country?" [1=not at all; 7= FDI is a key source of new technology". (e) For this indicator, survey respondents were asked to answer the question "To what extent do rules governing foreign direct investment (FDI) encourage or discourage it? [1=strongly discourage FDI; 7=strongly encourage FDI" (f) Net Gains of skilled persons through migration is defined as the final Net Overseas Migration (NOM) of skilled workers (i.e. permanent skilled plus temporary 457 visa holders). The latest figure is a forecast. (g) Churn values are calculated as the sum of arrivals plus departures.

Table notes: (i) Data is presented in calendar year format. Where the data is in financial years, it is expressed in terms of the year where the financial year begins e.g. 2010-11 is shown as 2010. (ii) The 'Australia's score' field presents the Australian values used in the OECD comparisons. (iii) This is the arithmetic (simple) average of the OECD country scores. (iv) This is the arithmetic (simple) average of the top five OECD countries in a ranked list. (v) This represents Australia's distance from the frontier as defined by the average of the top five ranked OECD countries. It is calculated as $100 * (\text{Top five average} - \text{Australia's score}) / \text{Top 5 average}$. Where the solution is a negative value or zero, "no gap" is shown in the cell. (vi) OECD rankings are performed on those OECD countries for which data is available. Individual data availability may vary between indicators. "-" = data not available.

Trade engagement

Trade is one of the most powerful modes of international engagement, as it requires connecting producers and users in global supply chains across borders. In 2011, trade that is the sum of exports and imports of goods and services was equivalent to 41% of Australia's GDP and has not changed much since 1995 (Table 1.1). More than 38,400 Australian firms were exporters of goods in 2011.²⁹ This figure is low compared with the OECD average, which has a value higher than the GDP (107%); Australia ranks 30th in the OECD on this measure.³⁰ Trade with Asia was about a quarter of Australia's GDP, a figure that has remained constant over the five years prior to 2011.³¹

This aggregated trade data masks some of the important factors associated with trade, such as the value added embedded in products and services that are traded. The introduction presented the concept of Global Value Chains (GVCs), which emphasises the idea that the 'quality' of trade engagement is associated with trade activities that have high added value. The OECD has recently compiled a database that allows the development of indicators that relate to the value added of traded goods.

The changing pattern of Australia's export markets, chiefly the recent surge in mining exports to China and other Asian countries, has been the single greatest influence on structural change and current economic conditions in the Australian economy. Since 2003, over half of Australia's per capita income growth has come from improvements in the terms of trade, driven by the mining boom.³² Australia's export sector has been particularly advantaged by the complementary nature of China's economic rise—the metals and energy intensity of its industrialisation and urbanisation and its geographic proximity.

Chart 1.1 shows the level and composition of Australian exports. Total merchandise and service exports more than doubled from \$146 billion in 2003–04 to \$315 billion in 2011–12. It is important to note that nearly all of this increase is due to the increase in the export of minerals and fuels, which more than quadrupled from \$35 billion to \$161 billion over the same period. Exports in raw commodities represented 9.6% of the GDP, taking Australia's ranking on this indicator to 3rd among the OECD (Table 1.1).

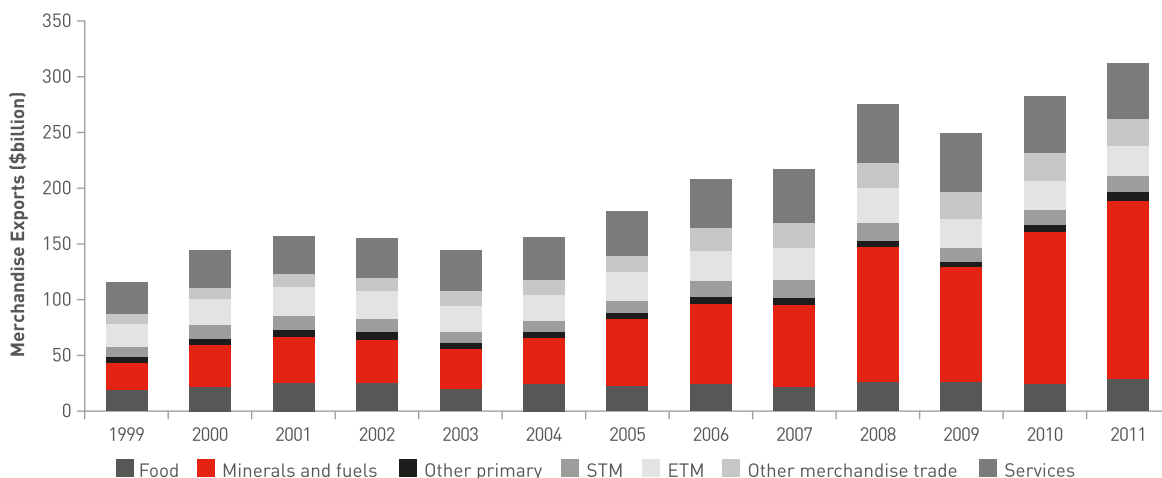
29 ABS (2013) *Characteristics of Australian Exporters 2011–12*, cat. no. 5368.0.55.006. Note: Data on the number of exporters is not available for the service sector. This data includes only goods exporters with an ABN.

30 Trade is the sum of exports plus imports. The value of trade can be higher than GDP.

31 DFAT(2013) *Composition of Trade 2012*. Department of Foreign Affairs and Trade, Canberra. P.20. ABS (2012) *Australian System of National Accounts 2011–12*. cat. no 5204.0.

32 OECD (2012) *2012 Economic Review Australia*, OECD Publishing.

Chart 1.1 Composition of Australian Exports (level), 1999–00 to 2011–12 (current values)



Source: DFAT (2012) Trade in Primary and Manufactured Products, Australia, 2011–12; DFAT (2012) Trade in Services, Australia, 2011–12; DFAT (2012) Composition of Trade 2011–12.

While there has been substantial growth in minerals and fuels exports, the export category of Elaborately Transformed Manufactures (ETMs),³³ which includes some highly complex products generally associated with high value add, R&D and innovation³⁴ was at roughly the same absolute level of \$28 billion in 2011–12 as it was in 2006–07. In fact, the ETM exports category experienced the least growth of any category between 1999 and 2011, growing only 2.8% annually. This reflects the effect of structural change in the Australian economy and the high value of the Australian dollar. The consequent decline in ETM share of total exports is particularly sharp—from around 17% of Australian exports in 1999–2000 to just 9% in 2011–12. Absolute values of ETM exports have increased by only about \$1 billion between 2001 (\$26 billion) and 2011 (\$27 billion). Services contribution to total exports also declined quite sharply from 25% of exports in 2003–04 to just 16% in 2011–12 (Chart 1.1). Although in absolute values services export registered an increase from \$36 billion to \$50 billion over the same period.³⁵

The OECD³⁶ characterises Australia's linkages to Global Value Chains (GVCs) as weak, not as a result of volumes of Australian exports, but because of the type of products exported.³⁷ According to the OECD most Australian sectors are not well linked to GVCs because Australian exports depend less on foreign imports compared with other countries. The data behind this assessment also shows little change between 1995 and 2009.³⁸ For example, the import content of South Korea's exports is more than 40%, while that of Australia is less than 15%.³⁹ Generally, there is deep integration within GVCs across Asian countries that results from complementary specialisation of production networks between these countries.⁴⁰

33 TRIEC classification classifies traded goods according their level of transformation in primary unprocessed goods (e.g. live animals and minerals); primary processed goods (e.g. food and fuels); simple transformed manufactured goods—STMs (e.g. mineral manufactures and metals); elaborately transformed manufactured goods—ETMs (e.g. chemicals and engineering products) and other products (e.g. gold and arms of war).

34 The view that ETMs have comparatively higher value added, R&D, and innovation to other categories is somewhat challenged by data on R&D intensity and total R&D expenditure. For example, professional and technical services show an R&D intensity higher than manufacturing, and mining has comprised close to one quarter of business expenditure on R&D in recent years.

35 Australian Government (2013) *Trade in Primary and Manufactured Products, Australia, 2011–12*, Department of Foreign Affairs and Trade (DFAT), Canberra; Australian Government (2013) *Trade in Services, Australia, 2011–12*, DFAT, Canberra; Australian Government (2013) *Composition of Trade 2011–12*, DFAT, Canberra. Note: Measuring trade in services requires complex methodologies most likely resulting in an underestimation of its contribution to exports.

36 OECD (2012) *Australian Manufacturing in the Global Economy*, a study for the Australian Government (DIISRTE), OECD Publishing.

37 *Ibid.*

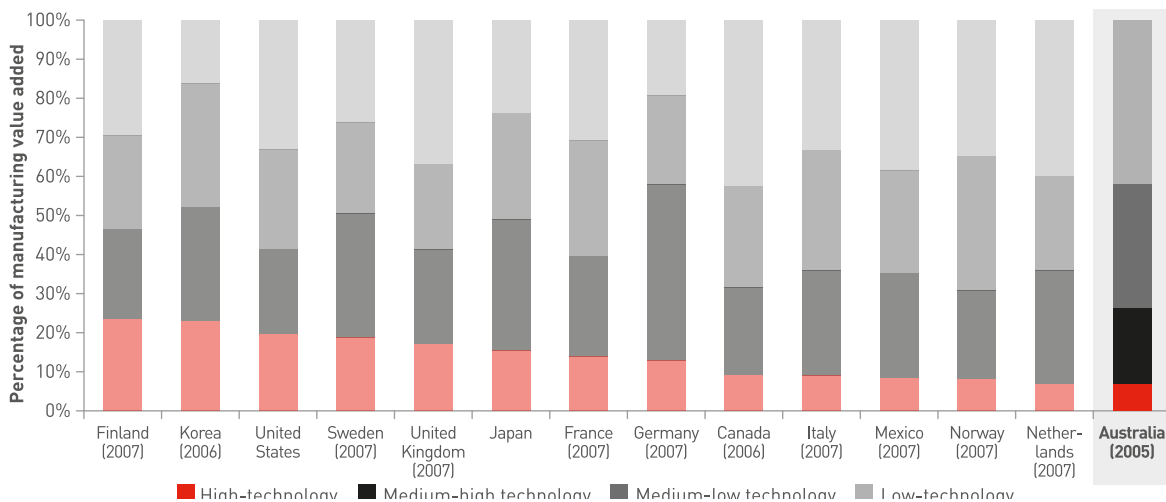
38 OECD (2012) *Australian Manufacturing in the Global Economy*, study for the Australian Government, (DIISRTE), OECD Publishing. Based on data of the trade of intermediate goods and services, the OECD (See De Backer K & Moussiégt L (2011) *Export competition: price or quality? OECD Working Party on Globalisation of Industry Report (DSTI/IND/WPGI(2011)2*, unpublished) developed an index to assess a country's participation in GVCs. This index consists of the sum of foreign value in Australian exports (in % of total exports) plus Australian value added incorporated in other countries (in % of exports by these other countries).

39 OECD (2010) *Economic Globalisation Indicators*, OECD Publishing.

40 WTO & IDE-JETRO (2011) *Trade Patterns and Value Chains in East Asia: From Trade in Goods to Trade in Tasks*, World Trade Organization, Geneva.

Australia's weak integration with GVCs is because our exports are increasingly concentrated on unprocessed minerals and fuels, hence the content of both local and foreign value in Australian exports is low.⁴¹ Even Australia's manufacturing output specialises in low and medium technology intensity sectors (Chart 1.2), implying that most of the value added is associated with industries with relatively low product complexity such as basic metals or food and beverages. These types of industry are either upstream in the supply chain (e.g. primary aluminium and steel) or at the final stages of processing (processed food) and do not integrate in most typical high value-added global supply chains, such as those associated with complex electronics and aerospace products.

Chart 1.2 Value added in manufacturing output, by technological intensity classes, 2008, by country (As a percentage of manufacturing value added)



Sources: OECD Structural Analysis Database (STAN); ABS (2009) Experimental Estimates for the Manufacturing Industry, cat. no 8159.0.

Note: The chart is based on the Technology intensive classification of manufacturing as part of the International Standard Industrial Classification (ISIC)—Revision 3.⁴²

Markets for Australia's minerals and fuels are disproportionately drawn from its key Asian trading partners (Chart 1.3). In 2011–12, more than 75% of Australian exports of minerals and fuels were to the five largest Asian export destinations—China, Japan, Korea, India and Taiwan. However, these five markets comprised just 17% of Australia's exports of Elaborately Transformed Manufactures (ETMs) and only 24% of our services exports. Conversely, 33% of Australian exports of ETMs and 25% of services exports were to just three English-speaking non-Asian export markets; namely, the United States, New Zealand and the United Kingdom.⁴³

In 2011, approximately two-thirds of Australian exports of goods and services were to East Asia alone, with a five-year growth trend of 13.2% cent per annum. While the five-year growth trend for primary products to East Asia was 20.2% per annum, exports of manufactures were flat-lining, with a five-year decline of -0.4%. Growth in exports of services to East Asia has been moderate, showing a five-year trend (to 2011) of only 4.2% per annum.⁴⁴

41 OECD (2012) *Australian Manufacturing in the Global Economy*, study for the Australian Government, DIISRTE, OECD Publishing.

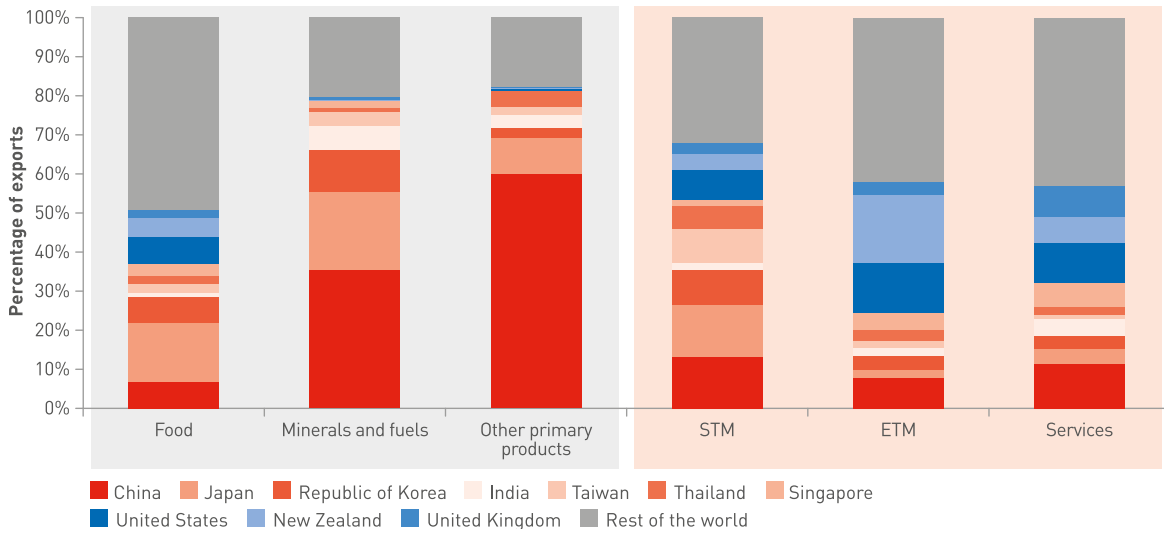
42 High technology intensity: Aircraft and Spacecraft (353) Office, accounting and computing machinery (30)

Pharmaceuticals (2423) Radio, TV and communications equipment (32) Medical, precision and optical instruments (33); Medium high technology intensity: Electrical machinery and apparatus nec (31) Motor vehicles, trailers and semi-trailers (34) Chemicals excluding pharmaceuticals (24 less 2423) Railroad equipment and transport equipment nec (352 + 359) Machinery and equipment nec (29); Medium low technology intensity: Coke, refined petroleum products and nuclear fuel (23) Rubber and plastic products (25) Other non-metallic mineral products (26) Building and repairing of ships and boats (351) Basic metals (27) Fabricated metal products, except machinery & equipment (28); Low technology intensity: Manufacturing nec; Recycling (36–37) Wood and products of wood and cork (20) Pulp, paper, paper products, printing and publishing (21–22) Food products, beverages and tobacco (15–16) Textiles, textile products, leather and footwear (17–19).

43 DFAT (2011–12) *Trade in Primary and Manufactured Products, Australia*, Department of Foreign Affairs and Trade: Canberra, DFAT (2011–12) *Trade in Services, Australia*. Department of Foreign Affairs and Trade: Canberra

44 Australian Government (2012) *Australia's Trade with East Asia 2011*, DFAT, Canberra, Tables 2 and 10.

Chart 1.3 Composition of Australian exports by destination, 2011–12



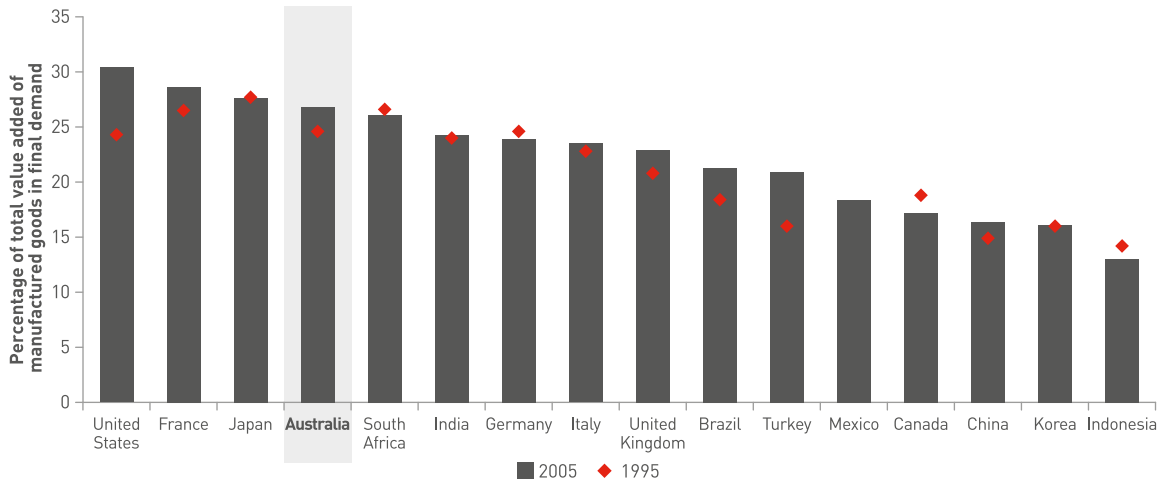
Source: DFAT (2011–12) Trade in Primary and Manufactured Products, Australia, Department of Foreign Affairs and Trade: Canberra, DFAT (2011–12) Trade in Services, Australia. Department of Foreign Affairs and Trade: Canberra.

This pattern of demand in Asian economies may change as incomes and patterns of consumption transform overcoming decades.⁴⁵ Given the existing size and further potential growth of Asian markets, even relatively small gains through innovative, diversified goods and services may lead to large gains in exports. If Australia is to diversify its export profile to its major markets, it will need to innovate and enhance business and cultural capabilities in relation to these countries.

One of the ways Australia can diversify is by increasing the content of valuable services in other activities such as manufacturing. This business model innovation would represent a change in activity from just manufacturing and assembling to more complex activities that embodied other services. OECD data shows that Australia seems to be well positioned to adapt its manufacturing sector by incorporating services, as 27% of the final value added of manufacturing can be attributed to services. This value is larger than most other countries (Chart 1.4). This trend may be reflecting an increase of outsourcing of services to other specialised firms to reduce costs or increase quality of manufacturers' product offering.

⁴⁵ Leahy A & Jensen PH (2011) Australia's Engagement with Asia 1990–2010, *Australian Economic Review*, 44(4), 418–26; Garnaut R (2012) Through the looking glass: Innovation in China in 20 years' time, *Australian Economic Review*, 45(4), 457–62.

Chart 1.4 Services sector value-added embodied in manufacturing output, 1995 and 2005 (as a percentage of total value added of manufactured goods in final demand)



Source: OECD (2011) Science, Technology and Industry Scoreboard

Service sector global engagement

Services sectors, including education services and tourism exports to Asia, have shown enormous dynamism in the last decade. Some analysts have suggested that services trade will play an increasingly important role in Australia's trade with Asia if current trends in demographics in the region continue.⁴⁶

Data compiled by the Pricewaterhouse Coopers (PwC) Melbourne Institute Asia Link Index shows that services trade between both Australia and Asia and Australia and the rest of the world have been growing at a significant rate (80% and 43% respectively in the period 2000–11).⁴⁷ One example of a service industry that is export oriented is education services.⁴⁸ Australia over the years has created an internationally competitive export industry associated with education services. International education is now Australia's largest services export market, contributing 30.2% of total services exports and occupies a third or fourth position in Australia's top exports behind only coal and iron ore.⁴⁹ In 2011 total exports of education services to Asia were \$9.8 billion⁵⁰ or 48.2% of Australian services exports to Asia.⁵¹

Higher education represents about 66% of all onshore earnings from international education, although vocational education and English language teaching also make an important contribution to sector exports.⁵² The sector's exports have declined since 2009, but remain strong. In 2011, 557,425 international students were enrolled in Australia.⁵³

Chart 1.5 shows trends in services sector trade with Asia. The large dark grey bar in Chart 1.5A corresponding to travel services is mainly due to the contribution of education-related travel expenditure on a range of services, including tuition, food, accommodation, local transport and health services, and business travel services.⁵⁴ International education is further discussed in Chapters 3 and 4.

46 Harcourt T (2012) *The power of proximity – Australia's next wave of global engagement in the Asian Century*, ANZ Services Report 2012, PwC, Melbourne Institute and Asia Link Index, Melbourne, pp. 4–6.

47 PwC & Melbourne Institute (2012) *Services at a Glance*, ANZ Services Report 2012, PwC, Melbourne Institute and Asia Link Index, Melbourne, p.8.

48 International education and tourism are export industries in the sense that they receive foreign currency although most of the activity occurs locally.

49 Marginson S (2012) *Education*, ANZ Services Report 2012, PwC, Melbourne Institute and Asia Link Index, Melbourne, pp. 20–25.

50 In 2007–08 prices.

51 *Ibid.*

52 Australian Education International (2012) *Export income to Australia from international education activity in 2011*, Research Snapshot May 2012, Australian Education International, Canberra.

53 Australian Education International (2012) *International Student Enrolments in Australia 1994–2011*, <http://www.aei.gov.au/research/International-Student-Data/Pages/InternationalStudentData2011.aspx>.

54 International Monetary Fund (IMF) (2009) *Balance of Payments and International Investment Position Manual*, 6th edition, IMF, Washington, DC.

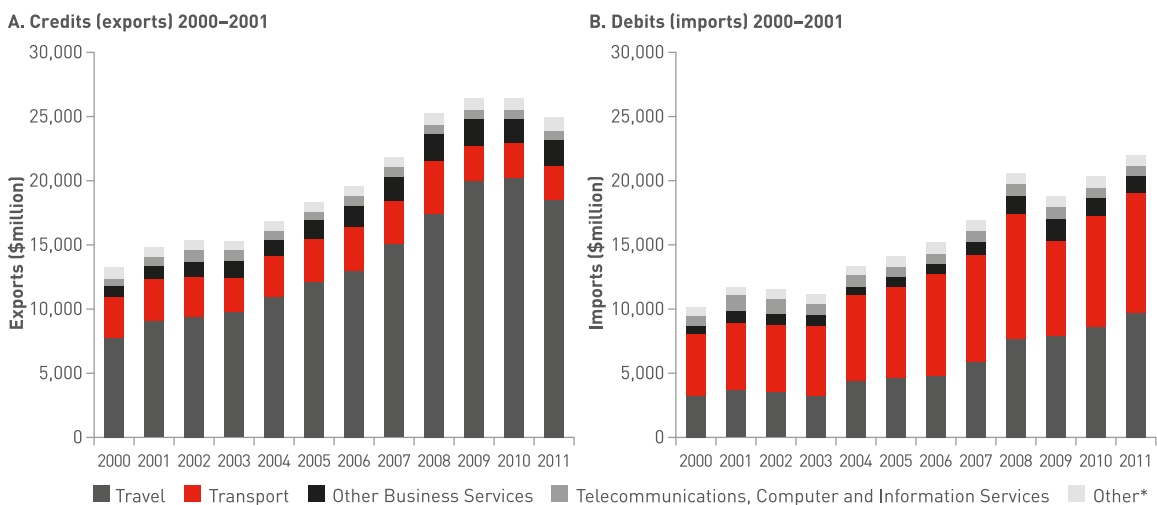
Linkages between Australia and Asia in sectors such as transport, financial services and telecommunication services show relatively small growth or, in some cases, negative growth during the decade to 2011. In some of these cases there are sector-specific regulations overseas that represent a competitive disadvantage for Australian firms trying to operate in these markets.⁵⁵ There are also issues of regional specialisation, macroeconomic conditions and national competitiveness that have been responsible for particular patterns of trade and trade imbalances in these industries.

While Australian services exports to Asia have shown small growth and decline after the global financial crisis (GFC), imports showed a healthy growth. Singapore and Hong-Kong have contributed to most of this growth as they serve as regional hubs and gateways for trade with growing Asian markets. These two countries accounted for 49% of the value of Australia's trade in transport services.⁵⁶

One strategy for diversifying exports is to increase services exports to priority Asian countries. While commodity exports are dominated by China, Japan, Korea and India, the profile of Australia's services exports is quite different. Apart from China, which is Australia's largest export market for both commodities and services with \$5.7 billion worth of services exports in 2011-12, the other top five service export markets are all predominantly English-speaking; namely, the United States (\$5.2 billion), the United Kingdom (\$3.9 billion), New Zealand (\$3.6 billion) and Singapore (\$3.1 billion).⁵⁷

Of Australia's approximately \$50.6 billion in service exports in 2011-12, \$30.7 billion was education, tourism and business travel. Service exports aside from travel-related (such as transport, technical, business, telecommunications and financial services), are even more weighted toward English-speaking countries. Only some \$600 million, or less than 1% of Australia's total exports to China are in services other than travel-related as opposed to \$3.6 billion for the US and even \$2 billion to Singapore.⁵⁸ For a relatively high value-add service export like intellectual property charges, the US is by far our largest export market at \$247 million compared to only \$24 million for China.⁵⁹

Chart 1.5 Australian exports (panel A) and imports (panel B) of services with Asian countries by sector, 2000-2011



Source: ABS (2012) *International Trade in Services by Country, by State and by Detailed Services Category*, cat. no. 5368.0.55.004.

55 Davis K (2012) *Education, ANZ Services Report 2012*, PwC, Melbourne Institute and Asia Link Index, Melbourne, p. 37.

56 PwC (2012) *Transport, ANZ Services Report 2012*, PwC, Melbourne Institute and Asia Link Index, Melbourne, p. 28.

57 Australian Government (2013) *Trade in Services Australia 2011-12*, DFAT, Canberra, Table 9.

58 *Ibid*, Table 13.

59 *Ibid*, Table 19. Note: Values of intellectual property charges sourced from Department of Foreign Affairs and Trade differ from those reported by the ABS in the publication *International Trade in Services by Country, by State and by Detailed Services Category*, cat. no. 5368.0.55.004. ABS uses calendar year and DFAT financial year.

Firm size and engagement

Chart 1.6 shows the contribution to exports of selected industry sectors by firm size. Large firms in all sectors but construction (a minor exporter by volume) represent more than 80% of that sector's exports. Although there are well-known factors associated with economies of scale that facilitate exports for large firms, this data suggests that there are additional constraints for Australian SMEs in engaging in exports, hence, in participating in Asian value chains directly. It is important to note that many of the final products that are exported by large firms may include parts and components produced by SMEs. This would represent an indirect link of SMEs to global value chains.

In terms of export growth, SMEs have been significantly less dynamic than large firms over the last five years. ABS data⁶⁰ shows that while export growth between 2006–07 and 2011–12 by large firms was 61% in current prices, medium-sized firms registered very low growth (3%) and small-sized firms export growth was moderate to low at 10% over the same five-year period. There are considerable variations between industry sectors. For example, in manufacturing, negative growth appears in all firm sizes, but the contraction is particularly significant in large manufacturing firms (-24%). Medium sized mining firms show a healthy growth (33%), but small firms a sharp decline (-33%). Even in construction, where SMEs contribute more than 30% to the \$669 million annual exports (2011–12), only large firms have shown significant growth over this period (176%). Small firms had negative growth and medium sized firms only grew by 3% between 2006–07 and 2011–12. The only sector that exhibits robust growth across all firm sizes is agriculture, forestry and fishing.

Counts of exporters indicate that more than 38,400 businesses are exporting. Of this number, 11% are large firms, 53% medium sized and 36% small sized.

Few Australian businesses cite overseas markets as their main source of income (2% in 2010–11) and most businesses particularly SMEs (70–91%) have the general public or other SMEs as their main source of income.⁶¹ Some sectors such as Mining are an exception with up to 14% of businesses citing exports as their main source of income. However, it is clear that innovation is a proactive tool for competing in international markets for most Australian industries. Innovation-active micro-, small-, medium- and large-sized businesses are 321%, 300%, 172% and 180% more likely than equivalent non innovation-active businesses to export their goods and services.⁶² Innovation-active micro-, small-, medium- and large-sized businesses are also eighteen, eight, ten and two times more likely than equivalent non innovation-active businesses to target new export markets.⁶³

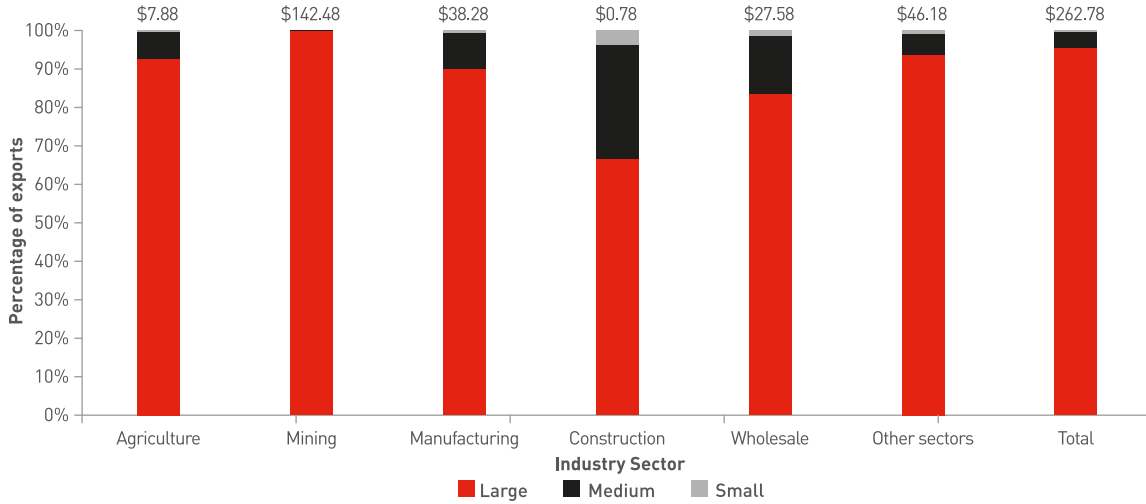
60 ABS (2012) *Characteristics of Australian Exporters, 2011–12*, cat. no. 5368.0.55.006.

61 ABS (2012) *Selected characteristics of Australian businesses, 2010–11*, cat. no. 8167.0.

62 *Ibid.*

63 *Ibid.*

Chart 1.6 Contribution of large, medium and small firms to exports by selected industry sectors 2011–12 (labels indicate total exports of the sector in billion)⁶⁴



Source: ABS (2013) *Characteristics of Australian Exporters, 2011–12*, cat. no. 5368.0.55.006.

Note: The definition of exporter firms follow these criteria: small exporters – having fewer than 20 payees and estimated annual GST turnover range less than \$1 million and exports of less than \$1 million during the reference period. Large exporters—having 200 or more payees or estimated annual GST turnover range of \$20 million or more or exports of \$20 million or more during the reference period. Medium exporters—all businesses other than those defined as small or large. Data on the number of exporters is not available for the service sector. Include all goods exporters with an ABN. The export values reflect exports of businesses that are classified according to the ANZSIC categories. Export values do not reflect classification based on product exports.

Success factors in global engagement

Recent OECD analysis shows that factors explaining manufacturing export growth vary considerably across countries. The OECD analysis uses a ‘shift-share’ analysis to explain how a country’s export growth is affected by several variables, notably world trade itself, the country’s mix of trading partners, as well as the mix of products that it exports. Once other factors are accounted for, the residual term can be interpreted as an index of export competitiveness.⁶⁵ These factors are shown in Chart 1.7.

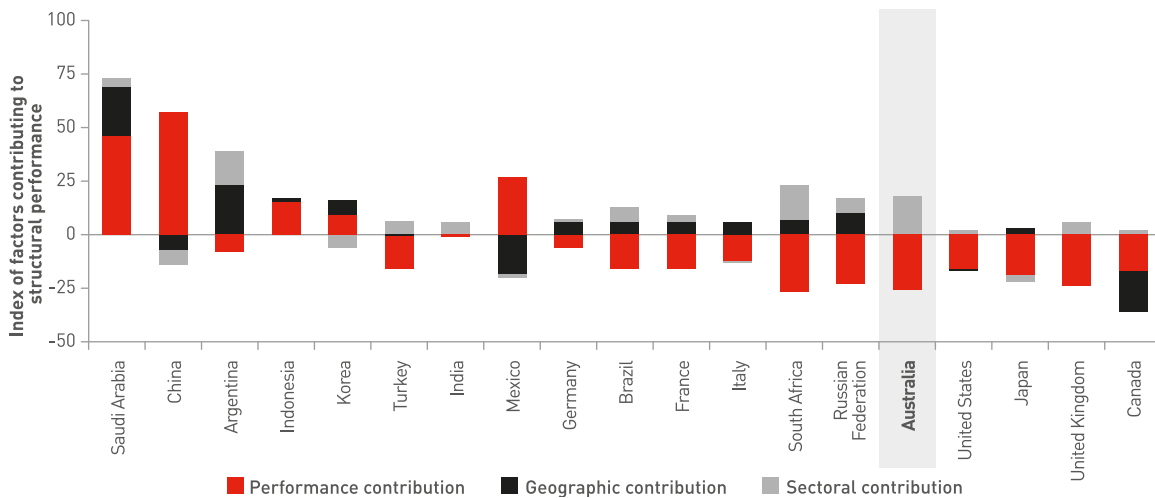
The sectoral effect refers to the degree to which export growth can be attributed to the specialisation in products where export demand is high. Chart 1.7 (grey bar) suggests that export growth in Australian manufacturing is partially explained by manufactures that are mining-related.⁶⁶ Interestingly, the geography factor (black bar), which is related to fast-growing markets such as those in the emerging economies of Asia, do not have an appreciable contribution to the growth of Australian manufacturing exports. This may suggest that Australian manufacturers have not been taking advantage of the fast-growing markets (e.g. Asia) in contrast to manufacturers in other countries such as Germany and France. This data suggests that Australian manufacturers could do better in tapping into growing Asian markets. Finally, the residual factor associated with the performance or competitiveness of Australian exports has been dragging export growth. This situation also affects other advanced nations such as the UK, the United States, Japan and Canada (Chart 1.7). It is expected that the impact of the higher dollar will also be a major factor in explaining why export competitiveness performance has a negative contribution to Australian manufacturing export growth.

⁶⁴ The data from the chart provides an analysis of the number and characteristics of Australia’s goods exporters. Data on exporters of merchandise trade are compiled from data sourced from the Australian Customs and Border Protection Service (Customs) and from the Australian Taxation Office’s (ATO) Australian Business Register.

⁶⁵ Beltramello A, De Backer K& Moussiégt L (2012) *The Export Performance of Countries within Global Value Chains (GVCs)*, OECD Science, Technology and Industry Working Paper 2012/02, OECD Publishing.

⁶⁶ OECD (2012) *Australian Manufacturing in the Global Economy*, Paper Commissioned by DIISRTE, OECD Publishing. Note: Calculations based on OECD Bilateral Trade database.

Chart 1.7 Factors explaining the growth of Australian manufacturing exports (2005–10)



Source: OECD (2012) Australian Manufacturing in the Global Economy. Paper Commissioned by DIISRTE. OECD Publishing, Calculations based on OECD Bilateral Trade database.

Knowledge of Asian markets and culture as a competitive factor

'Asian literacy' is a term increasingly used by the Australian Government and businesses, reflecting a perceived need to increase our knowledge of Asia and Asian languages in schools, the business community and society more broadly. While this has been identified as important, there are limited studies of Asian literacy in the business sector. CPA Australia & Enright undertook a survey of Australian and non-Australian businesses about the importance and Australia's level of performance of key factors that drive competitiveness relevant to Asia. The survey indicates that Australian businesses typically place a relatively low level of importance on Asian markets compared with domestic markets. Agriculture and mining are the exception. Respondents from these two sectors rated the importance of Asian markets significantly higher than respondents from other industry sectors.⁶⁷

Interestingly, the survey also shows that Australian respondents generally consider that having access to bilingual skills is relatively unimportant, while non-Australian respondents rated this as an important factor driving competitiveness in Asia.⁶⁸ The CPA & Enright analysis concludes that many Australian businesses still remain poorly placed for taking advantage of the opportunities of the emergence of Asia. On the other hand, those Australian businesses that build strong knowledge of Asian markets and conduct business in Asia on a regular basis will not only be able to mitigate the risks of over-reliance on the domestic market, but also be better placed to take advantage of the emerging Asian economies.⁶⁹ This report and the following case studies show that technological capability needs to be complemented with tailored business models and soft skills around language and culture.

67 CPA Australia & Enright MJ (2012) *Australia's competitiveness survey: Preliminary findings*, CPA Australia, Melbourne.

68 *Ibid* p.5

69 *Ibid* p.6

FEATURE: INNOVATIVE CHINA: TRENDS, CHALLENGES AND OPPORTUNITIES

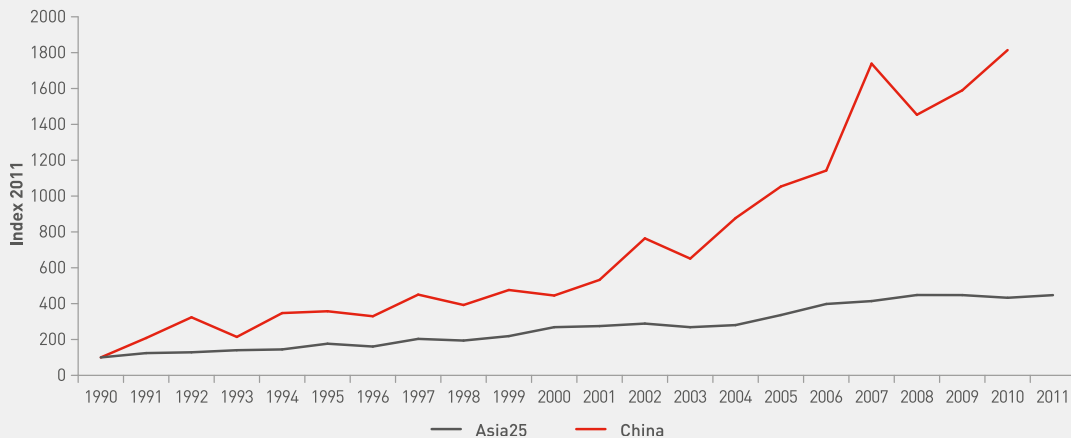
By Professor Paul H. Jensen, University of Melbourne.

There is a growing awareness in Australia of the unique position in terms of the rise of China as an industrial superpower. Although it has long been regarded as the 'factory of the world', there is a growing consensus that China is going to need to move up the value-added chain in the future. In other words, it is going to have to become more innovative if it is going to continue its economic rise. The opportunity that presents itself for Australia is a once-in-a-generation opportunity to build social, educational and professional ties with a nascent innovative powerhouse which will hopefully help us secure our prosperity in the decades to come.

The good news is that there are many in industry, policy, government and academia that are acutely aware of this and are keen to take a forward looking stance on our relations with China. So, rather than harping on at length about the problems faced by Australian firms in terms of enforcement of their intellectual property (IP) rights in China—which are no doubt important issues, but ones which will take international action to help remedy—our thought-leaders are keenly focused on the positive ways in which we can reach out to China.

To see why this is important, consider the magnitude and speed of Australia's economic and social links with China in recent years. The index⁷⁰ (below Chart) shows our engagement with China over the period 1990–2010; which has outpaced that with the rest of Asia (of course, from a lower base).

Chart F1.1 Australia engagement with China and Asia



Source: Leahy A. and Jensen P.H. (2011), "Australia's Engagement with Asia, 1990–2010", *Australian Economic Review*, vol. 44, no. 4, pp. 418–26

Much of this growth has been driven by China's huge demand for our mining products. As China becomes a more sophisticated economy – and there are notable examples that this is happening⁷¹ – Australia will also need to rethink how it interacts with China and the types of goods and services it trades with China. Changing the way we view China is an essential part of the challenge of the emergence of innovative China. This includes a deeper appreciation of the 'soft' aspects of dealing with China including cultural awareness and understanding.

As Professor Ross Garnaut has recently pointed out, although the China of the future will have first world standards, it is likely that it will be different from other first world countries.⁷² If we don't understand these differences, we run the risk of missing out on being an important link in the global innovation supply chain of the future. At present, Australia accounts for around 3% of the world's knowledge. If we want to improve this (or even increase it) then we need to pay greater heed to the emergence of China as an innovation nation. In my view, there is little doubt that China will be at the forefront of the next wave of technological revolutions

⁷⁰ The index is an unweighted average of its seven components: trade, investment, research and business development, education, migration, tourism and aid. For details, see: Leahy A & Jensen PH (2011) Australia's Engagement with Asia, 1990–2010, *Australian Economic Review*, 44, 418–26.

⁷¹ Wu X (2012) The evolution of innovation policy in China: A brief introduction, *Australian Economic Review*, 45, 463–66.

⁷² Garnaut R (2012) Through the looking glass: Innovation in China in 20 years' time, *Australian Economic Review*, 45, 457–62.

Case studies

CASE STUDY: SIGNOSTICS



Caption: Signos RT S3-5 Portable Handheld Ultrasound System— *designed, developed and manufactured in Australia by Signostics Ltd.*

Images provided by Tim Pearce, Signostics Ltd.

South Australian medical devices company, Signostics Ltd, is a developer and manufacturer of portable, handheld ultrasound devices that cater for Australian, United States and European markets. The company's newest product, Signos RT, is also set to reach the Asian market in 2013. Signostics has transformed its business from a small Australian start-up company in 2005 with a great idea to an Australian based international company with an eye to continued growth in the future.

With its head office in Adelaide and additional sales operations in Palo Alto, California, Signostics launched its first generation Signos device into the veterinary market in 2009 before gaining regulatory approvals to enter the human medical device market in Australia, the United States and Europe.

Continuing to invest in research and development, Signostics launched its second generation Signos RT model in February 2013. This pocket-sized and light ultrasound device offers real-time imaging capabilities for quick and simple point of care applications such as e-FAST scans, pneumothoraces, AAA screening, bladder volumes, basic pregnancy assessments and ruling in obvious pathology. From its inception as a medical device company, Signostics has focused on making ultrasounds that are affordable and accessible by practitioners and their patients in urban, rural and remote locations. Signostics aims to make it cost effective for individual physicians and hospitals to use ultrasound at the bedside and thereby reduce clinical risks.

The creative use of key partnerships and collaborations has been crucial to the innovation and success of the company. The inspiration for this device originated in the creative partnership between co-founders Dr Neil Bartlett, a physician, and his brother Mr Stewart Bartlett, with





engineering expertise in the semiconductor industry. They both continue to grow the company as Chief Medical Officer and Quality and Regulatory Officer respectively.

Signostics retains its core software and hardware expertise in-house and other specialised skills are available locally. Similarly, the resources for conducting clinical evaluations are available through nearby Flinders Medical Centre, a public teaching hospital and medical school, co-located with Flinders University and the Flinders Private Hospital.

Signostics has also found partnerships with local companies to be productive. For example, Signostics has a contract manufacturing agreement with South Australian ophthalmic laser and ultrasound company, Ellex Medical Lasers Limited, to manufacture the transducers, the critical working component of the Signos RT, at the Ellex manufacturing facility in Adelaide. Additionally, Signostics contracts the production of the electronics and the assembly of the handheld display and probe unit to SRX Global, located in Melbourne.

In February 2013, Signostics announced a key distribution partnership with the Japanese company Konica Minolta Inc to sell Signostics products exclusively throughout Japan, China, India and the USA, which is now of greater significance following the recently announced FDA 510(k) clearance to market into the human medical market. Under this agreement, Signostics will act as the Original Equipment Manufacturer (OEM) to manufacture the Signos RT with the help of partner suppliers. Signostics will deliver it exclusively to Konica Minolta Inc. under their brand, Sonimage P3, to promote and sell via their existing supply channels in both the human and veterinary markets.

Signostics sees that this distribution partnership will facilitate its entry into the high growth, high population and vast healthcare of Asia and the United States and help to keep the cost of the products low by expanding the scale of production and at the same time increasing Signostics' revenue.

This partnership is particularly interesting because the Australian company will undertake the manufacturing in Australia while the Asian partner, a large multinational, will market and sell the product.

Similarly, Signostics has finalised an exclusive distribution partnership with Thermo Fisher Scientific to promote and distribute Signos RT in the Australian and New Zealand market through its Healthcare business.

The company envisages more key partnerships in Asian countries such as Indonesia, Vietnam and Korea in the future which will help build on the growing distribution channels existing across Europe.

For more information visit www.signostics.com.au

CASE STUDY: COOK MEDICAL



Caption: Cook Medical Australia and Cook Medical APAC's headquarters in Brisbane.



Caption: Laboratory work is an essential part of the manufacturing process of medical devices.

Images provided by Dylan Mckinn

Cook Medical established its first presence in Asia Pacific at the end of the 1970's setting up an Australian base that focused on manufacturing and exporting medical devices to the markets within the Pacific Rim and Asia Pacific region as well as locally.

Based in Brisbane, this business is part of the world's largest privately owned medical device company which has pioneered many of the medical devices now used to perform minimally invasive medical procedures and is home to the only manufacturing site in the world that produces custom made stent grafts for the treatment of abdominal aortic aneurysms.





Employees work in areas ranging from R&D to the production of endovascular grafts which are meticulously made by hand in the local Brisbane manufacturing facility.

The Brisbane manufacturing facility is Cook Medical's Asia Pacific headquarters, employing over 450 staff locally and 1050 across the Asian Pacific region.

The business has a presence in China, Japan, India, Taiwan, South Korea, Hong Kong, Malaysia, Thailand and Singapore with a view to grow the business in both Indonesia and Vietnam in the near future.

Cook Medical sees itself as a 'patient first' company. It is central to every decision that is made and where true innovation is achieved. Investing in products that save lives is considered the highest innovative achievement, above all else.

- To forge an identity to grow business operations in the Asia Pacific region from a group of individual countries, operating with autonomy, to a coordinated sales, marketing and logistics team. A number of objectives were outlined as priorities for the business to succeed in the Asia Pacific Region: Investing in infrastructure developments to develop and assist export sales.
- Improving the enterprise resource planning (ERP) system and business reporting to provide accurate and timely information to all levels of the business including the capability to report this information in all major regional languages
- Investing in region-wide systems (e.g. IT, finance, logistics, etc.) to assist in the drive towards a coordinated, self-funded region designed to manage an increasing number of orders from a growing customer base while continuing to provide a high level of customer service.
- Establishing local companies and support infrastructure
- Embracing the local business culture of each particular market
- Investing in local people
- Exploring additional support staff locally to expand the export operations
- Changing focus to embrace the whole paradigm of market development versus market share.

With these objectives in place, in 2012 Cook Medical Asia Pacific generated revenue of US\$389 million, an increase of 27.6% from 2011 which accounted for 20.4% of Cook's global sales, increasing Asia Pacific's contribution by 3% from 2011. Revenue generated from the sale of Australian manufactured products was AUD\$82 million of which \$72.5 million or 88.4% was exported.

As an exporter, Cook Medical Australia believes that to be successful in Asia, to understand local business culture is crucial. It is this reason why Cook Medical has a presence in all of the countries it deals with and one of the main reasons why the company has continued to succeed.

Cook Medical's investment in local people has proven to be the greatest asset available to a company establishing itself in a foreign market.

Next, Barry Thomas, the Managing Director of Cook Medical Australia, provided his personal account of successfully working in various and diverse Asian countries.

CASE STUDY: THE COOK MEDICAL AUSTRALIA STORY FROM THE CEO



Caption: Cook Medical Australia's managing director, Barry Thomas, in front of the world's only custom made aortic stent graft manufacturing facility.

Images provided by Dylan Mckinn

Being the largest privately owned medical device manufacturer in the world has been a huge advantage for Cook Medical, especially in Asia. At the height of the GFC it allowed us to forge ahead with investment and development of markets in the Asian region, something we would not have been able to achieve were we not a public company. When others were pulling out of Asian markets we were setting up

The above example is one that I am very familiar with because it's my business. A couple of years ago, Cook Medical was doing all of this in the Asia Pacific region. Things were going gang busters and we were in the best shape we could possibly dream of. Rather than sit back and marvel at our achievements we decided that it was time to develop the next part of our business, one that would take us to even greater heights and help us achieve greater success than we had already achieved.

Now we knew that this would not be an easy task but we had no idea just how hard it would be. Developing a business for a foreign market throws up more challenges that you can think of. There are so many different aspects that need to be checked and on more than one occasion we began to doubt whether we had made the right decision. Alas, Asia is the most populated region in the world and for us to be able to provide our products to billions of people made the decision to develop the business there an easy one.

Sure it would be great if it was as easy as taking your product there, selling it and getting paid but in my experience that would also be the downfall of your business as well. The thing about dealing in Asia that I have found is that if you do not embrace the local business culture then don't expect to be in business in that market. Be respectful of what the locals are doing no matter how much you disagree because this type of thinking can be catastrophic to the development of your business and could also lead to the demise of your business.

Learning this lesson at an early stage for us was the greatest business development tool we could have asked for. It allowed us to find the gaps within our already successful business and mould them and shape them to fit the particular market we were interested in entering.

And the proof is in the pudding. Nearly five years after all of this happened we have almost topped half a billion dollars in sales, the amount of ideas and innovations we have access to because of our business development in the region is forever increasing but most important of all, in what we do, we have helped save lives. This, from where I stand is the most important aspect of our business.

For more information visit www.cookmedical.com

CASE STUDY: AUSBIOTECH FOSTERING LINKS WITH ASIA

Image provided by Lorraine Chiroiu

In acknowledgement of the leading role Asia, and in particular China, is expected to take in the future of life sciences globally, AusBiotech is focused on engagement, with business missions, partnerships and investment delegations to the region.

AusBiotech is Australia's biotechnology industry organisation, representing more than 3,000 members – working to grow and sustain the biotechnology sector in Australia.

Building on existing partnerships with Asian-based organisations, such as HKBIO, the Hong Kong industry association for medical devices and the China Medical Device Association, with which AusBiotech has memoranda of understanding, AusBiotech has also established a regular investment showcase for Australian companies in Hong Kong and recently held the inaugural Australia China Life Science Summit.

Hong Kong, with its direct access to China, is developing as a pivotal hub in the Asia Pacific region, and this is especially important from an Australian perspective as a regional neighbour. Private investment by Chinese and Hong Kong-based venture capitalists has burst forth in recent years, peaking at \$1 billion in 2010 and reaching \$573 million in 2011. The average Chinese VC investment in life sciences in 2011 was \$25 million, compared with \$10 million in the US.

AusBiotech and Hong Kong-based Beacon Events, organiser of the largest resource sector investor event in the Asia Pacific Region – Mines and Money – have partnered to deliver biotechnology investor meetings in Hong Kong and Sydney until 2015.

Beacon Events serves the increasingly important emerging markets of Asia, providing cutting-edge, market-driven programs and synergy with AusBiotech's move into the fast-growing investment hub in Hong Kong.

The Asian Century has also seen focus in the region shifting toward science and technology, with investment in research and development increasing by more than 20% in China alone in recent years. The rate at which Asia develops and adopts technology is expected to continue to accelerate in coming years, underpinning economic growth. China has made a clear commitment to develop life sciences with biotechnology set as one of seven priority industries in China's 12th Five Year Plan. Australia and China have together established a joint Science and Research Fund, and China is expected to become the second largest pharmaceutical market in the world by 2015.

The Australia China Life Science Summit was held in March 2013 to share knowledge and gain expert views and experiences from others who have successfully created linkages and developed partnerships in the region. Key speakers included the Hon John Brumby – Former Victorian Premier, Vice-Chancellor's Professorial Fellow at the University of Melbourne and Monash University and Director, Huawei Technologies (China); and the Honourable William S. Cohen, Former U.S. Senator and Defence Secretary, Chairman of The Cohen Group and Senior Advisor to DLA Piper, Vice Chairman, US-China Business Council and the Australia China Business Council.

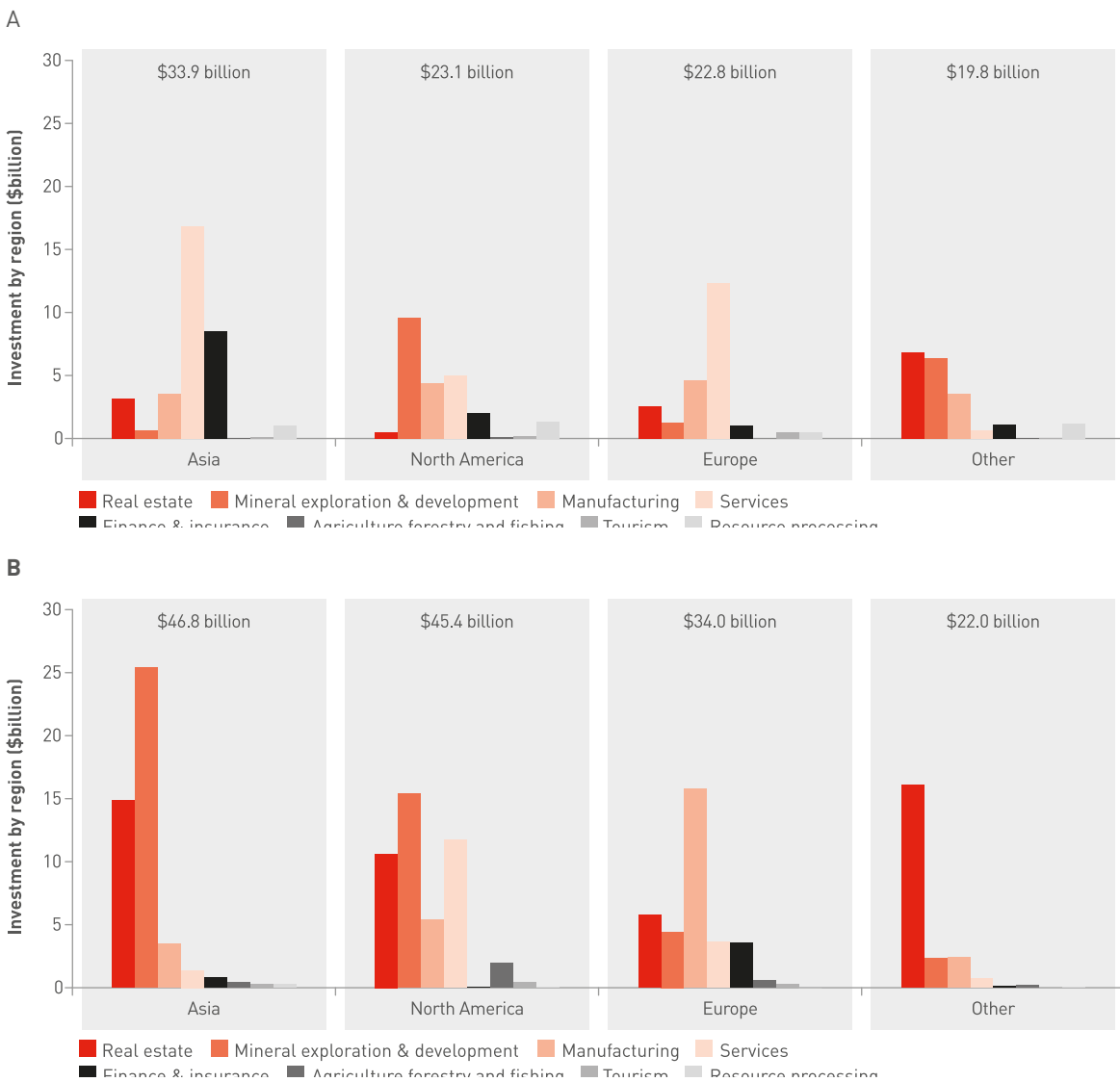
While there are already numerous examples of Sino-Australian partnership in life sciences, evidenced in part by the 50 Hong Kong fund managers currently investing in Australian public biotech companies, AusBiotech expects this interest to grow vastly in the coming years. AusBiotech's work in the region is looking to establish and build upon relationships within the region, with a view to closer ties in future.

For more information visit www.ausbiotech.org

Foreign Investment

Investment flow is an important indicator of economic engagement. Foreign direct investment (FDI) has a positive impact on economic growth, both for developing and developed countries.⁷³ FDI is a key vehicle for transfer of technology and management capability. FDI implies long-term commitment from the investor who acquires business facilities, employs local staff, etc. hence it represents a strong type of linkage. On the contrary, debt finance and portfolio investment can be recalled relatively quickly. The Asian financial crisis of 1997, for example, resulted in a deficiency of short-term debt finance, but did not have a significant impact on the level of foreign direct investment in the Asian region.⁷⁴ This fact may have helped the quick recovery of industrial production in the Asian region after the crisis as industrial assets were put in operation once economic conditions improved.

Chart 1.8 Foreign Direct Investment approvals in Australia 2000–01 (panel A) and 2011–12 (panel B)



Source: Foreign Investment Review Board (2012) Annual Report 2011–12.

The net levels of FDI inflows as percentage GDP in Australia (at 2.7%) have not recovered since 2007 and still are under 3% of GDP (Table 1.1). This figure is higher for Australia than the OECD average, which is only 1.9% of GDP.

Chart 1.8 gives a snapshot of Australia’s FDI inflows in the years 2000–01 and 2011–12 by region and by source of investment. The sum of FDI by regions does not add to the total reported in the chart; the

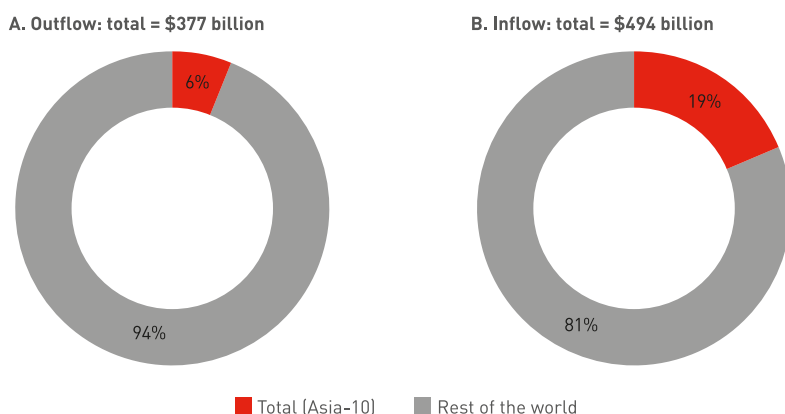
73 Borensztein E, De Gregorio J & Leec J-W (1998) *Journal of International Economics*, 45(1), 115–135 ; Hermes N & Lensink R (2003) *The Journal of Development Studies*, 41(1), 142–163.
 74 Evans T (1999) *Economic Nationalism and Performance: Australia from the 1960s to the 1990s*, Ninth Annual Colin Clark Memorial Lecture, Discussion Paper No. 258, University of Queensland, Brisbane.

difference is due to joint applications with foreign investors.⁷⁵ The patterns of FDI flows by region have changed considerably between 2000–01 and 2011–12. In 2000–01 services represented more than 43% of foreign investment approvals, followed by manufacturing (14%) and mineral exploration and extraction (11%). In contrast, in 2011–12 real estate (34%) and mineral exploration and development (30%) contributed more than 64% of total FDI (or \$110 billion).

Interestingly, the overall change in FDI flows from 2000–01 to 2011–12 has been driven by specialisation of regions (and countries) in particular sectors. For example, Asian investors switched dramatically from services to mineral exploration and real estate in this period. This was mainly due to the increasing focus of China and Japan on mining, and of China and Singapore on real estate investments. As an individual country source of FDI flows, China registered a massive increase from \$311 million to \$16.2 billion over the same period. North America almost doubled its FDI from \$23.1 billion to \$45.4 billion and registered large increases in mineral exploration, real estate and services. Europe shows a more balanced distribution of its FDI flows across sectors. Europe has been leading foreign direct investment in manufacturing, mainly due to the investment of the UK in this sector, which totalled more than \$13 billion in 2011–12.

Australian outward investment is also a way to view Australia's global integration. Asia hosted only 6% of Australia's outward stock of FDI in 2010 (Chart 1.9). This has risen slightly over the last five years from 4% in 2006 (Chart 1.9). By comparison, Australia drew almost 19% of inward investment from Asia—10% in 2010 (Chart 1.9).⁷⁶ According to the Business Council of Australia's report, Asian markets on the whole continue to be relatively closed to foreign investment, particularly in the services sectors. Australia ranks well in indicators such as the number of start-up procedures to register a business (Table 2.4). This is not the case for most of the Asian countries (Singapore is an exception and usually ranks very high in the index of ease of doing business).⁷⁷ However, within the Asian region, important changes in the direction of outward investment are taking place. For example, Australia's outward stock of FDI in China has more than doubled from \$2.6 billion to \$7.0 billion between 2009 and 2010 and China replaced Singapore as the largest recipient of Australian direct investment in 2010. The level is still low compared with the \$100 billion Australia has currently invested in the United States.⁷⁸

Chart 1.9 Australia's stock of foreign direct investments outflow (panel A) and inflow (panel B)



Sources: ABS (2011) *International Investment Position, Australia: Supplementary Statistics, Calendar Year 2011*, cat. no. 5352.0; Business Council of Australia (2011) *Assessing Australia's Trade and Investment with Asia*. Paper prepared by ITS Global for the Business Council of Australia, Melbourne.

Note: Values use an implicit GDP deflator (IMF 2011). Asia's top 10 are: China, India, Indonesia, Japan, Malaysia, Rep. of Korea, Singapore, Taiwan, Thailand and Vietnam.

International engagement on business R&D and innovation

Previous Australian Innovation System reports have shown that only 2.4% of Australian innovators engage in international collaborative innovation (or 1.6% of all businesses in Australia). Not surprisingly, Australian businesses rank poorly compared with other OECD countries on this measure (at 25th out of 26 OECD countries; see Table 1.1). Relative to other OECD countries, Australian industry appears to be more insular than other OECD countries with domestic collaboration on innovation ranking 12th out of 26 OECD countries.⁷⁹ More disaggregated data shows that levels of both SME and Large business international

⁷⁵ Foreign Investment Review Board (FIRB) (2012) *Annual Report 2011–12*, FIRB, Canberra.

⁷⁶ Business Council of Australia (2011) *Assessing Australia's Trade and Investment with Asia*, ITS Global for the Business Council of Australia, Melbourne, p. 46.

⁷⁷ World Bank. 2013. *Doing Business 2013: Smarter Regulations for Small and Medium-Size Enterprises*. Washington, DC: World Bank Group. DOI: 10.1596/978-0-8213-9615-5.

⁷⁸ *Ibid.*

⁷⁹ *Australian Innovation System Report 2011*, pp. 86–87.

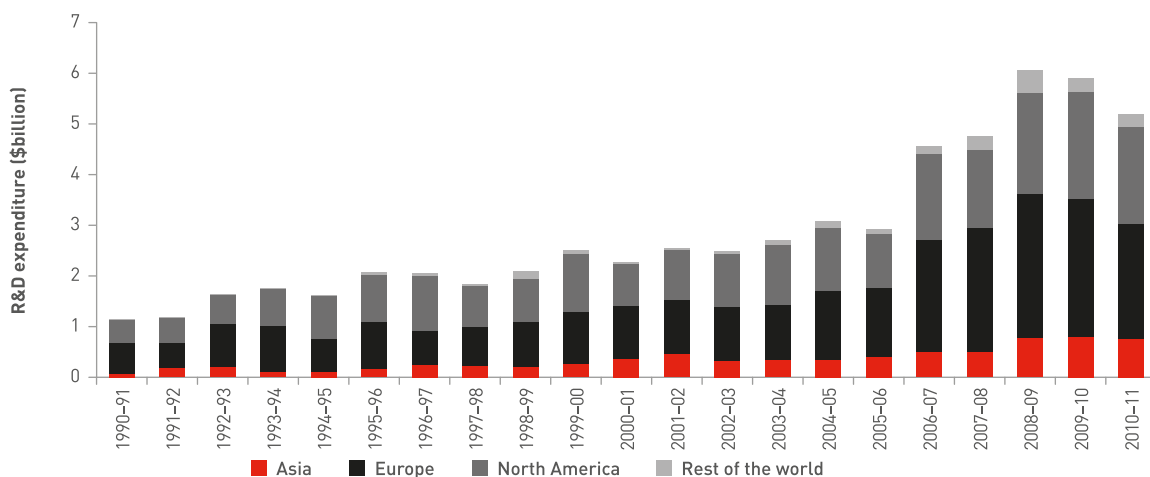
collaboration on innovation also rank poorly at 25th and 26th out of 26 OECD countries, respectively.⁸⁰ These results reinforce the relatively low levels of international engagement on foreign investment in business R&D discussed above (Table 1.1). Taken together the data suggests Australia has a generally low level of integration into one of the high value added parts of global value chains, namely innovation (See Introduction). Most other OECD countries are much more likely to engage in international collaboration on innovation (the OECD average is 18% compared to 4% for Australia), many of which are also more likely to be engaged in world-first innovation.⁸¹ Collaboration on innovation is highly correlated with world-first innovation (See Chapter 2). If Australia is to take advantage of the Asian Century through competitive goods and service offerings, more businesses need to be undertaking collaborative innovation, particularly with global leaders.

Business research and development by foreign companies is an important mechanism of engagement on innovation.⁸² A foreign company that invests in Australia in R&D is committing resources not only because it trusts Australian capacity to deliver on innovation, but also because it is assuming the risks that R&D entails with the expectation that the decision of investing in R&D will improve the firm's competitiveness and profitability. Australia may benefit because of positive externalities: the accumulation of knowledge, skills and expertise associated with this R&D.

Charts 1.10 to 1.13 present different aspects of business R&D expenditure undertaken by multinationals in Australia.⁸³ According to registration data from the previous R&D Tax Concession program, total R&D expenditure by foreign multinationals in Australia was \$5.2 billion in 2010–11, representing 28% of the total R&D expenditure by firms registered in this program. This percentage is similar to that registered by ABS BERD statistics of 29% (Table 1.1).⁸⁴ Europe and North America still contributed the largest majority of foreign business R&D investment—80% in 2010–11 (Chart 1.10) although this proportion has declined from 94% in 1990–91. Asia's contribution has increased faster than any other region, although from a small base. In 1990–91 Asian countries' expenditure on business R&D in real terms was only \$61 million; by 2010–11, this had increased 13 fold to more than \$818 million, but still represented only 15% and 4% of the total foreign R&D and total R&D respectively.

BERD investment patterns by Asian multinationals has changed significantly in the last two decades (Chart 1.11). In the 1990s Japan's contribution to Australia's research and development was approximately 77% of all Asian investment. This percentage decreased in the 2000s to only 36%. In 2010–11 Japan was still the main Asian contributor to BERD with \$332 million (or 38% of Asia).

Chart 1.10 Foreign business R&D expenditure in Australia by region of source (constant \$million 2010–11)



Source: R&D Tax Concession Registration Data, AusIndustry, Department of, Industry, Innovation, Climate Change, Science, Research and Tertiary Education.

Note: Price deflators are specific for business R&D activity in Australia. Price deflators have been provided by ABS on special request.

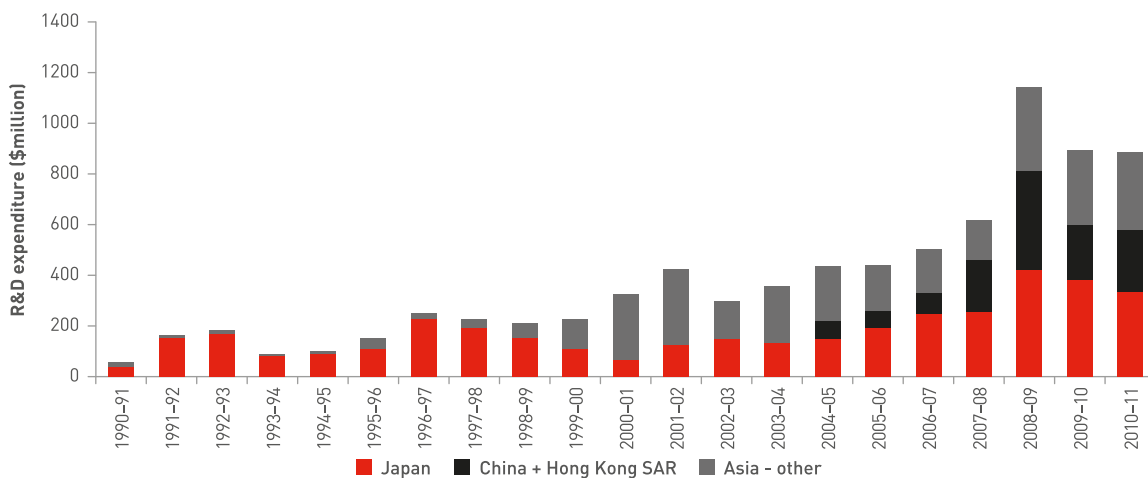
80 OECD (2011) *OECD Science, Technology and Industry Scoreboard 2011*. Data for Australia has been provided by the ABS on special request. *ibid.* p.23.

82 International research sector engagement is discussed in Chapter 4.

83 In this section foreign multinationals' Foreign multinational R&D is defined as the R&D expenditure of companies that have reported an ultimate holding company (UHC or parent company headquarters) overseas when registered in the R&D Tax Concession Program. In the case of Asian multinationals, these companies have indicated that the ultimate holding company (or parent company headquarters) is located in Asia. An Asian country is defined following the definition of the Department of Foreign Affairs and Trade.

84 R&D Tax Concession Registration Data, ABS (2011) *Research and Experimental Development, Businesses, Australia, 2009–10*, cat. no. 8104.0.

Chart 1.11 Foreign business R&D expenditure from selected Asian countries (constant \$million 2010–11)



Source: R&D Tax Concession Registration Data, AusIndustry, Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education.

Note: Price deflators are specific for business R&D activity in Australia. Price deflators have been provided by ABS on special request. Data for China and Hong Kong SAR before 2004-05 is not publishable due to confidentiality considerations.

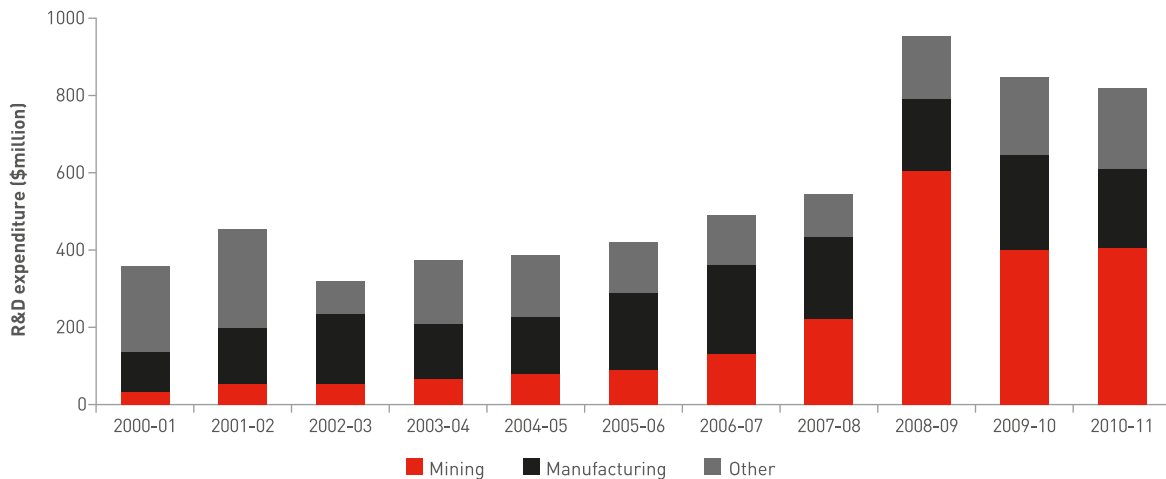
Since 2007–08 China and Hong-Kong SAR⁸⁵ have provided the second largest contribution to R&D among Asian countries, overtaking Singapore. R&D investment by Chinese multinationals reached \$247 million in 2010–11. Considering its size, it is important to note that Singapore multinationals (included in Asia-other Chart 1.11) have contributed significantly to R&D spending in Australia, particularly in 2000–01 and 2001–02 when Singapore was the main Asian spender in R&D. Singapore’s overall contribution has been about 20% of the total R&D expenditure by Asian countries between 2000–01 and 2010–11.

Asian multinationals’ R&D expenditure by sector also shows a changing pattern (Chart 1.12). In the early 2000s, information media and telecommunications (aggregate in ‘other sectors’) dominated Asian expenditure in R&D in Australia.⁸⁶ Manufacturing became the main focus of Asian R&D from 2002–03 to 2006–07 and from 2008–09, the mining sector has led Asian BERD in Australia. Charts 1.8 and 1.12 also suggest a correlation between the changing patterns of sectoral R&D expenditure by foreign countries and the foreign direct investment discussed earlier in the chapter. For example, the large Asian investment in information media and telecommunications in R&D in the early 2000s coincides with strong Asian direct investment in this sector over the same period (classified as services in Chart 1.8). Similar trends are seen in relation to Japanese BERD and manufacturing and, more recently, the strong Chinese investment in mining R&D. It is important to note that these national specialisations represent only small proportions of the total sectoral research and development expenditure. For example, Japanese manufacturing multinationals’ R&D expenditure in Australia (\$163.7 million) represented only 3% of total manufacturing R&D expenditure and Chinese multinationals’ expenditure in mining R&D (\$194 million) was only 4.5% of the total mining R&D in 2010–11.

85 SAR: Special Administrative Region.

86 Electricity, Gas, Water and Waste Services; Information Media and Telecommunications; Professional, Scientific and Technical Services, Agriculture and the rest of industry sectors have been aggregated to maintain confidentiality.

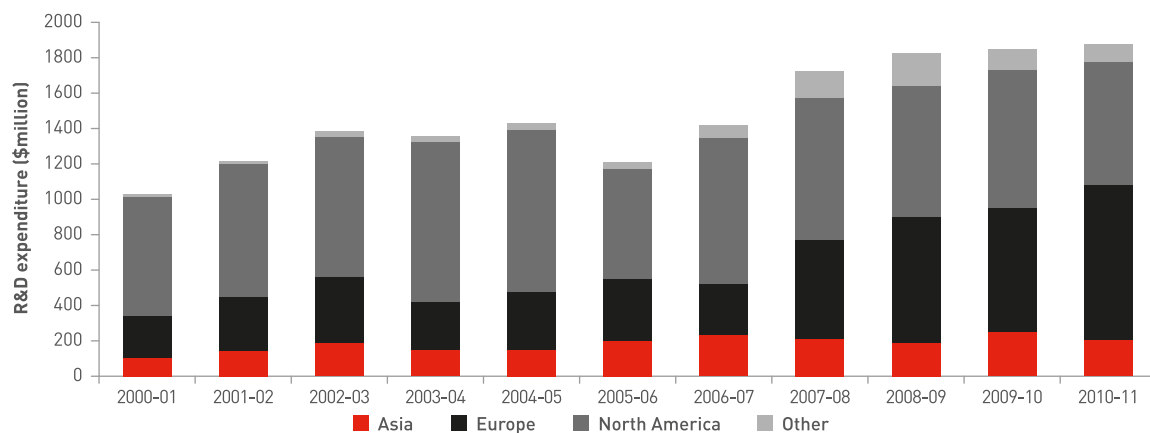
Chart 1.12 R&D expenditure by Asian multinational firms in Australia by selected ANZSIC sector (\$million constant 2010–11)



Source: R&D Tax Concession Registration Data, AusIndustry, DIICCSRTE.

Note: Price deflators are specific for business R&D activity in Australia. Price deflators have been provided by ABS on special request.

Chart 1.13 R&D expenditure by multinational firms in manufacturing in Australia by region (\$million constant 2010–11)



Source: R&D Tax Concession Registration Data, AusIndustry, DIICCSRTE.

Note: Price deflators are specific for business R&D activity in Australia. Price deflators have been provided by ABS on special request.

Historical data of foreign R&D investment in manufacturing is shown in Chart 1.13. In the decade between 2000–01 and 2010–11 this amount almost doubled—from \$1029 million to \$1877 million in real terms. This increase was led by European multinationals that increased their R&D investment in the Australian manufacturing sector four-fold—from \$239 million to \$876 million in real terms. Interestingly, contrary to the other regions, this trend seems unaffected by the global financial crisis that started in 2008.

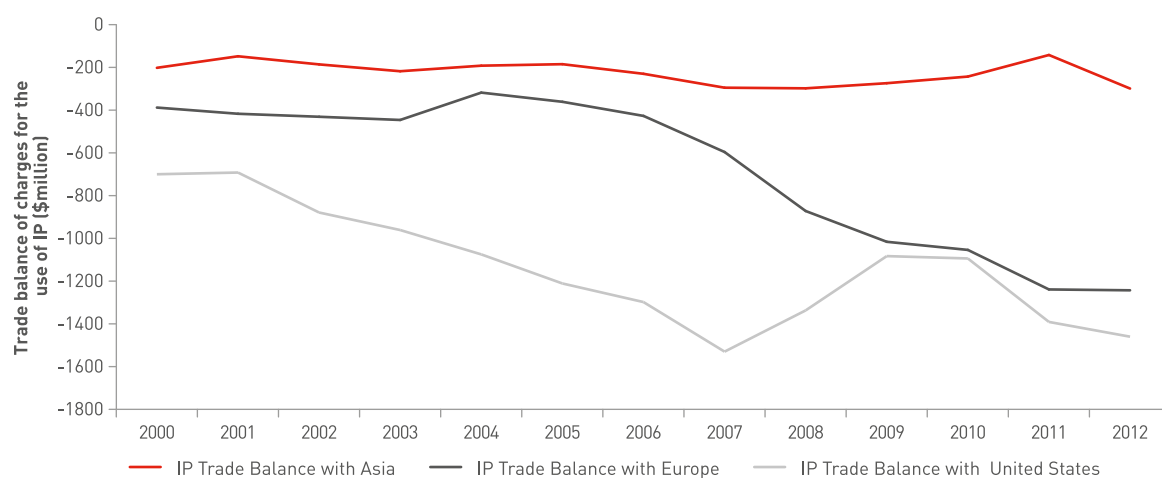
Intellectual property knowledge engagement

Chart 1.14 shows the balance of inflows and outflows of payments for the use of intellectual property (IP) between Australia and Asia, Europe, and North America. Australia is predominantly a country of adopters and modifiers of foreign innovations and shows an increasing dependence on foreign IP (Chart 1.4). The chart also indicates that Australia’s dependence on intellectual property from Europe and the United States has increased sharply in the last decade, while trade balance in the payment of IP with Asia has been stable over the decade.

Despite poor overall rankings on international collaboration on business innovation, other parts of the innovation system show positive signs of increasing international engagement. The level of international research collaboration by the public research sector has increased dramatically over the last decade

(See Chapter 4) and the proportion of patents with foreign co-inventors has doubled to 18% in 2009 up from 1995 levels (Table 1.1). However, domestic and international patenting rates and other IP protection activities have been in decline in absolute terms since 1995 and are low relative to other countries (See Table 2.2). Not all sectors of the economy utilise patenting and other intellectual property protection to the same degree. Further analysis of sectoral innovation systems is required to account for these structural differences. A lot of the international engagement appears to be pre-competitive collaboration and suggests the main conduits for ideas entering Australia may be via public research hubs and through adoption/modification of products introduced to Australian markets from elsewhere. Australia still remains a net importer of intellectual property, reaching \$3.1 billion net imports of IP in 2012 (Table 1.1) growing almost three-fold in the preceding decade. Australia paid to \$459 million for IP to Asian countries in 2012 and this was mainly to Japan. Australia received \$160 million from Asia for payments of IP in 2012; the resultant balance was a deficit of \$299 million.

Chart 1.14 Trade balance of charges for the use of intellectual property (\$ millions)



Source: ABS (2012) *International Trade in Services by Country, by State and by Detailed Services Category*, cat. no. 5368.0.55.004.

Skilled migration and engagement with Asia

Migrants to Australia are an important resource for the nation's innovation system.⁸⁷ Skilled migration can foster a resilient innovation system by upskilling labour markets through knowledge and skill transfer. Migration also offers opportunities to expand the depth and breadth of international economic and social engagement by building upon the networks, language and cross-cultural capabilities that migrants bring with them. The 2011 Census of Population and Housing indicated that some 27% of the Australian population was born overseas. Of these, 33%, or 1.75 million, were born in Asia,⁸⁸ making the Asian-born population 8.9% of Australia's total population (Table 1.2).⁸⁹

87 A review of some of the key international and Australian literature on migration and innovation can be found in: Smith R (2011) *Migration and the Innovation Agenda*, DIISR Working Paper 2011-02, Australian Government, Canberra.

88 The top countries by migrants' birth place in the 2011 census were the United Kingdom (1,101,100 million), New Zealand (483,400 million), China (319,000), India (295,400), Italy (185,400) and Vietnam (185,000). Out of the top ten, five were Asian countries—the others being the Philippines (171,200) and Malaysia (116,200). In addition, as many as 4.3% of the Australian population reported Chinese ancestry and 2% reported Indian ancestry. ABS (2012) *Cultural Diversity in Australia—Reflecting a Nation: Stories from the 2011 Census, 2012–2013*, cat. no. 2071.0.

89 Australian Government (2013) *Temporary entrants and New Zealand citizens in Australia as at 31 December 2012*, Department of Immigration and Citizenship (DIAC), Canberra.

Table 1.2 Top Five Country Rankings (excluding New Zealand) by Migration Category 2011–12

Country	Permanent Migration Program—Top five ¹	457 Grants—Top five ²	International Student Visa Grants— Top five ³	Census 2011 Country of Birth— Top five ⁴
Asian Countries				
India	1 st (29,018)	2 nd (11,940)	2 nd (33,764)	3 rd (295,400)
China	2 nd (25,509)		1 st (49,592)	2 nd (319,000)
Philippines	4 th (12,933)	4 th (5,000)		
Malaysia			5 th (9,316)	
South Korea			3 rd (12,407)	
Taiwan				
Japan				
Vietnam				5 th (185,000)
Non-Asian Countries				
UK	3 rd (25,274)	1 st (15,750)		1 st (1,101,100)
South Africa	5 th (7,640)			
Ireland		3 rd (6,320)		
United States		5 th (4,840)		
Germany				
Brazil			4 th (9,695)	
Italy				4 th (185,400)

Source: [1] Department of Immigration and Citizenship 2012, 2011–12 Migration Program Report: Program year to 30 June 2012, Australian Government, Canberra, p.5. [2] Department of Immigration and Citizenship 2012, Subclass 457 State/Territory summary report, 2011–12 to 30 June 2012, Australian Government, Canberra, table 1.05, p.4. [3] Department of Immigration and Citizenship 2013, Student visa program trends, 2005–06 to 2011–12, Australian Government, Canberra, table 2.03, p.20. [4] Australian Bureau of Statistics 2012, Cultural Diversity in Australia—Reflecting a Nation: Stories from the 2011 Census, 2012–2013 (ABS Catalogue No. 2071.0).

Indicator notes: New Zealand has been excluded due to the special visa arrangement that exists with Australia.

Migration and international population movements to Australia occur through a variety of mechanisms. Temporary movements include tourism, education, international conference and business travel, seasonal circular migration and working holiday makers. Longer term international movements include permanent migration, temporary skilled workers (subclass 457), international students and humanitarian assistance.

Under the Australian Migration Program one of the main pathways to up skilling the workforce in Australia is the Skill Stream of permanent migration, which targets migrants who have skills, proven entrepreneurial ability or outstanding capabilities that will contribute to the Australian economy.⁹⁰ During the 2011–12 program year, the Australian Migration Program comprised 185,000 places—125,755 in the skill stream, 58,604 in the family stream and 639 in ‘special eligibility’. This was an all-time record migration intake. The Migration Program for 2012–13 is set at an even higher level of 190,000 places.⁹¹

Reflecting the strong emphasis on the Skill Stream of recently arrived migrants, professionals accounted for 61% of the outcome in the skill stream in 2011–12. In addition, among the findings from the Department of Immigration and Citizenship’s Continuous Survey of Australia’s Migrants (based on surveys of recent migrants to Australia conducted from 2009 to 2011) were that around 70% of primary applicants in the Skill Stream (and 58% of primary applicants overall) held qualifications at the level of bachelor’s degree or above and as many as 31% held postgraduate qualifications (23% in the case of primary applicants overall)—levels far exceeding those of the general Australian population. Moreover, their fields of study were heavily weighted toward STEM (Science, Technology, Engineering, and Mathematics) disciplines. The most common fields of study of these recent migrants were engineering and related technologies (16%), health (12%) and information technology (9%).

⁹⁰ Australian Government (2013) *Australia’s Migration Trends 2011–2012*, DIAC, Canberra.

⁹¹ Australian Government (2012) *2011–12 Migration Program Report: Program Year to 30 June 2012*, DIAC, Canberra.

In terms of countries of origin under the official Migration Program in 2010–11, for the first time an Asian country, namely China, displaced the United Kingdom as the largest source country. In 2011–12, China was in turn displaced by another Asian country, India. China, India and the UK have consistently been by far the largest source countries under the Migration Program over the last five years. Of the top 10 source countries in 2011–12, seven were Asian, namely India (29,018), China (25,509), Philippines (12,933), Sri Lanka (5,577), Malaysia (5,508), South Korea (4,874) and Vietnam (4,773).

In addition to permanent migration, the temporary work skilled visa (or subclass 457 visa) allows eligible employers to address skills shortages that cannot be met from the local labour market by sponsoring overseas workers for up to four years. Reflecting the relatively high-skill level of 457 visa-holders, 69.2% of applications were granted for professional or managerial positions and the average base salary for all primary applications was \$85,400 in 2011–12.⁹²

In contrast to permanent migration, the top five countries of origin for subclass 457 holders in 2011–12 were the UK, Ireland and the USA or the Asian countries such as India (17.5%) and the Philippines (7.3%), where English is widely spoken. The number of Filipinos granted visas under the program more than doubled from 2010–11.⁹³

A 2012 study shows a strong relationship between 457 visa holders, the development of human capital and positively influencing Australia's innovation system through the training of Australian workers.⁹⁴ Nearly four in every five multinational companies canvassed in this survey reported that they used 457 visa holders to train and develop Australian workers, and 68.5% of employers said they were using 457 visa holders to train their Australian counterparts.⁹⁵ In terms of workplace performance, the majority of employers indicated that they were equally satisfied with Australian and 457 visa holders, although smaller firms had substantially higher satisfaction rates with 457 visa holders than larger firms.⁹⁶ Professionals accounted for 61% of the migrants in the skill stream in 2011–12.

The level of Australian international engagement, in particular with Asia, can be gleaned not only from migration statistics, as discussed above, but also by examining short term arrivals and departures data for professional activities. Historical trends of the sum of incoming travel (arrivals) and outgoing travel (departures) of people in the categories of business, education, conferences and conventions and employment are presented in Table 1.1.

Data on outgoing and incoming travel for business purposes from Australia between 1991 and 2011 indicates a 10% increase of outgoing travel to Asia, compared with 6.6% for all other countries over this period. By 2011 Australia's proportion of business travel to Asia had grown to 46% of all outbound business travel compared with 40% in 1991. In terms of business arrivals from Asia, the level of incoming engagement is less than the outgoing equivalent, with 38% of all business travel into Australia in 2011 coming from Asia. Numerically, North East and South East Asia accounted for the majority of these arrivals (124,580 and 119,390 respectively).

When convention and conference travel data are examined, an increase in Australia–Asia engagement is also notable. Over the period 1991–2011 Australians travelling to Asia for conference-related travel increased 13% to 41% of all outbound departures for this purpose, with the greatest rate of growth being most significant from North East Asia. Travel from Asia to Australia also increased significantly over this period (24–33%).

The number of Australians leaving for short-term work in Asia increased gradually by 6% (1991–2011), with South East Asia growing 11.5% as the most significant region for employment growth for Australian nationals (35,190 departures in 2011). Short-term employment arrivals from Asia increased from 26% to 35% of all arrivals to Australia over this 20-year period, with 102,210 workers arriving in 2011. Consistent with the analysis provided earlier on 457 visas, South East and Central Asia, dominated by the Philippines and India, provided the most significant growth as labour source regions for Australia.

92 Australian Government (2012) *Subclass 457 State/Territory summary report*, 2011–12 to 30 June 2012, DIAC, Canberra.

93 *Ibid.*, p.12.

94 Migration Council of Australia (2012) *More Than Temporary: Australia's 457 Visa Program*, Migration Council of Australia, Canberra. *Note:* This study was based on a survey of 3,812 workers on 457 visas and 1,600 employers who used the program was undertaken by the Social Research Centre (May–June 2012), was funded by the DIAC.

95 *Ibid.*, p.22.

96 *Ibid.*, p.18.

Aid

Australia is a significant contributor of international development assistance and, therefore, development in the Asian region. The aid program has multiple objectives including promoting stability, prosperity and sustainable development. Asia comprises around 51% of Australia's total aid budget, not including core contributions to multilateral organisations and other Overseas Development Assistance not attributed to particular countries or regions.⁹⁷ Over the next four years, Australia is expected to become the largest bilateral grant donor to East Asia and is already the largest bilateral aid donor to Indonesia.⁹⁸

There are a number of ways that Australian international development assistance can stimulate innovation in target countries and therefore potentially in Australia. First, the degree of assistance provided to a G20 country with a relatively large and rapidly growing economy such as Indonesia can enhance its capacity to contribute to innovation outcomes domestically and through their links to regional trade and investment. Other large, underdeveloped but fast growing economies like Vietnam and the Philippines are such future innovation partners for Australia.

Second, many of the fields of development assistance pertain directly or indirectly to the development of innovation systems. They include the emphasis on school education and scholarships to study at institutions of higher learning in Australia (such as the Australia Awards)⁹⁹ and the targeting of IT-related reforms. Examples of the latter include assisting Indonesia to publish court decisions online and assisting Cambodians to conduct online financial transactions using smart phones.¹⁰⁰ Trade-enabling support, so-called 'aid for trade', was an estimated \$663 million in 2011–12, or 13.6% of Australia's ODA.¹⁰¹

Third, development support and cooperation enhances people-to-people ties in which Australians work together with local communities, civil society organisations and government officials in target countries to tackle problems in a variety of areas—from governance and legislative reform to health, schooling and disaster relief. These ties cement relationships that will facilitate future trade and investment links and fosters cultural understanding. Meanwhile, as is the case with foreign investment, public sector and not-for-profit civil society cooperation requires upskilling and benchmarking local workforces against international standards, raising productivity in the process.

FEATURE: INDONESIA IN THE ASIAN CENTURY

By Professor Hal Hill (ANU) and Roger Smith

In terms of Asian century engagement and opportunities, Australia's near neighbour to the north ticks most of the boxes. It is a fellow G20 country, has the world's fourth largest population, is the world's 16th largest economy and is increasingly trumpeted as the world's third largest democratic system.

Besides China, Indonesia has achieved the most consistently strong economic growth of any major Asian economy in recent years. It posted growth of over 6 per cent per annum every year since 2007 with the exception of the global financial crisis year of 2009 (when it still recorded 4.6 per cent growth). However, this relative success in recent times belies a history of economic development that has been mixed at best. From heavy dependence on commodity exports, such as tin and rubber, during Dutch colonial times, Indonesia had become an economic basket case by the 1960s with economic decline and hyper-inflation in excess of 500 per cent per annum.

From the late 1960s under Soeharto's New Order regime, the Indonesian economy grew rapidly through attracting foreign investment and implementing sound economic policies under the auspices of the so-called 'Berkeley mafia' of technocrats. In order to reduce its dependence on oil and gas, from the 1980s onwards Indonesia also successfully adopted the 'East Asian' model



97 Australian Government (2013) *Aid Budget Statement 2013–14*, AusAID, Canberra, p.12.

98 Australian Government (2012) *AusAID Annual Report 2011–12*, AusAID, Canberra, pp.70, 72. Note: The extent of aid to Indonesia is particularly noteworthy since it is not only a fellow member of the Group of Twenty (G20), but also already enjoys the second fastest rate of growth (after China) in the G20.

99 <http://www.australiaawards.gov.au/>

100 *Ibid*, pp.6, 24.

101 *Ibid*, p.32.



of export-oriented industrialization through the development of textile, footwear and electronics manufacturing industries—often associated with iconic brands like Nike and Reebok. Mirroring developments in many other burgeoning Asian economies, the agricultural sector of the national economy fell from about 53 per cent in 1965 to around 12 per cent now, while per capita GDP rose six-fold. Enrolments in tertiary education increased from approximately 2,000 students at independence in 1945 to some 4 million today.

Growth was severely interrupted in 1997 when Indonesia was the country hardest hit by the Asian Economic Crisis (referred to as 'krismon' or monetary crisis in Indonesia). GDP contracted by 13 per cent per annum in calendar 1998 alone. However, the flip side of the economic and political crisis that saw the resignation of President Soeharto in May 1998 was a program of major political and institutional reform. Indonesia's first democratic legislative elections since the 1950s were held a year later in 1999 with reformist parties dominating. Political reform was further consolidated with the implementation of regional autonomy in 2001 (a decentralised system with many powers devolved to the sub-provincial district/city level) as well as the first direct presidential elections in 2004 won by current President Susilo Bambang Yudhoyono (SBY). SBY's constitutionally limited second five-year term will expire in 2014 when the next round of legislative and presidential elections are due to be held.

Indonesia continues to face severe challenges in combatting corruption, lifting human capital development, improving infrastructure, augmenting accountability and reducing the budgetary burden from fuel subsidies. However, to a large extent, the significant economic and political reform of the Reformasi era is already paying dividends with consistently high growth driven by increased political stability, surging Chinese demand for its natural resources, and the need to service steadily growing lower to middle class consumer markets. The country's proximity to and deepening integration with the rest of East Asia (especially to a major logistics hub like Singapore), its significant entrepreneurial drive (spreading out beyond its ethnic Chinese population) and one of the world's highest take-up rates of online social media are other pluses that Indonesia enjoys over and above its natural resource wealth. Meanwhile, its scale, as the world's largest population behind China, India and the United States, ensures that Indonesia's domestic market cannot be overlooked by investors. It is widely expected to be among the world's ten largest economies by 2030. The OECD has now even accorded Australia's near neighbour with BRIICS status—adding a second 'I' to the acronym for this purpose.

However, Australia's level of economic engagement has not kept pace with these developments. Despite Indonesia's GDP (in current prices) doubling from US\$432.2 billion in 2007 to an estimated US\$894.9 billion in 2012, Indonesia still only ranked as our 13th largest merchandise trading partner in 2011–12. The major exports were wheat, education-related travel, crude petroleum, aluminium, tourism (excluding education) and cotton.

This modest economic engagement among these two neighbouring G20 economies is partly explained by lack of complementarity; that is, for example both countries are major coal and LNG exporters. This economic structure shapes the nature of the bilateral relationship. Australia's trade with Indonesia and Southeast Asia in general, differs from that of the major resource-hungry Asian economies of China, Japan, Korea and India. But there are major opportunities elsewhere, particularly in education, a wide range of business services, and some niche manufactures. Moreover, the lack of complementarity does not fully explain the limited engagement. There is arguably less high-level awareness and understanding of Indonesia in this country than there was in the 1970s and 1980s. Indonesian language and studies in our universities has been languishing seriously for well over a decade. If Australia is to succeed in the Asian Century, it is precisely in countries like Indonesia where our business capabilities need to be refocused, refined and expanded on the basis of deeper understanding and education.

CASE STUDY: FUTURIS



Caption: Entrance to the Futuris manufacturing facility in Rayong, Thailand. Futuris is building a third facility in Thailand to support a number of global platforms.



Caption: Front seats packed and ready to be moved to Chery Automobile's production line in Wuhu China. Futuris has a joint venture with Chery – one of China's largest vehicle producers.

Images provided by Dexter Clarke

Futuris is a leading, award-winning Australian automotive components manufacturer.

Futuris designs, engineers and manufactures automotive seating and interior trim products, providing innovative solutions for both mature and emerging automotive markets. From a design





and engineering base in Australia, Futuris has quickly grown into the emerging markets of China, Thailand and South Africa as well as into North America, with further growth underway in both the Asia Pacific and Americas regions.

Flexibility and agility are core strengths. Market share is protected through strong partnerships, innovative business models, proven quality, competitive costs and high barriers to entry. With state of the art facilities employing best practice technologies and supply chain management systems, Futuris provides a flexible approach to the design and manufacture of high quality, complex and safety critical products.

Futuris' major customers include GM, Ford, AAT, Toyota, Chery, JAC, SAIC, Brilliance and Tesla.

Futuris also has a broadening range of non-automotive offerings that include cleantech manufacturing solutions and infrastructure products and services (through Plexicor Australia).

Futuris has been engaged in Asia for many years, firstly due to the need to develop global supply chains to support Australian vehicle producers but more so now to participate in those global supply chains. After conducting an 18 month long market assessment in China, Futuris entered the Asian market in 2005 with the establishment of their first joint venture business with Chery in the Anhui province of China. From that point on, Futuris has grown to have 4 manufacturing facilities in China, a regional headquarters in Shanghai and has now also grown into Thailand.

Futuris' Chinese business was originally focused on supplying domestic Chinese vehicle producers such as Chery and JAC as these businesses grew quickly to become leaders in the market. This strategy was employed by Futuris to get a fast start in a highly competitive market where all of the major global competitors already had well established businesses. This strategy has led to Futuris winning business with a number of major vehicle producers in China including SAIC and Ford.

The expansion into Thailand took a different path where Futuris maximised the excellent relationships it has with Ford and GM Holden in Australia to win business with these vehicle producers in Thailand. Futuris established its facilities in Rayong, an area of Thailand where Ford, GM and many other vehicle producers are investing heavily in new facilities. Being close to customers and selectively investing in the right places have been a critical part of Futuris' success in growing into Asia.

One of the keys to Futuris' success in Asian markets has come from the development of businesses which supply those markets. This has led to Futuris developing business models and product offerings which are in demand in Asia. As large western vehicle producers attempt to maximise their own opportunities in Asia, they now see Futuris as a business which is capable of developing products which are aligned with their brand and quality expectations yet are priced appropriately for those markets and able to be services in those markets.

Futuris' success in Asia has not been achieved overnight and they are the first to admit they made some mistakes along the way. The potential rewards are only just now beginning to pay dividends for Futuris and their experience places them well for further success in the future. For businesses just starting the journey into Asia, their advice is to be patient and make sure you have a business / product offering which is differentiated and innovative.

For more information visit www.futurisautomotive.com

CHAPTER 2: BUSINESS INNOVATION AND COLLABORATION

Business innovation is at the core of a well-functioning innovation system and a principal driver of productivity and a high standard of living (see introduction). Previous reports have discussed the role of innovation in depth.¹⁰²This chapter considers three elements of business innovation. First, it looks at collaboration between businesses and other actors in the innovation system. This is a continuation of an ongoing investigation into this area; one that has been examined in all previous Australian Innovation System reports. Second, business innovation in Australia is compared and benchmarked against international counterparts. This is crucial as it provides much-needed context on the adequacy of domestic innovation levels. Last, one of the significant measures of investment in innovation—investment in intangibles—is explored, building on the analysis presented on this topic in the Australian Innovation System 2012 report.

Collaborative innovation

Following from the definition of our national innovation system, an implicit characteristic of a high-performing innovation system is that the actors within it are interconnected and able to effectively collaborate, thereby maximising the sharing of resources and ideas. Intuitively, collaboration is not homogenous; it varies by the length of time, the parties collaborating and the intensity of the collaboration.¹⁰³This is one reason why collaboration data is so volatile.

Previous reports have demonstrated that business benefits from collaboration on innovation including increased productivity, profitability and export markets targeted.¹⁰⁴ Innovation almost doubles the likelihood of productivity growth in Australian businesses. Compared to businesses that don't innovate, innovative Australian businesses are 78% more likely to report increases in productivity over the previous year (Chart 2.1).

One area of collaborative innovation that has been of longstanding interest to the Australian Government is collaboration between researchers and businesses. Industry research collaborations tend to be longer term relationships and involve a significant investment of resources by both parties. It has been argued that these greater levels of investment and risk on average will lead to greater payoffs (including increased productivity gains).¹⁰⁵Chart 2.1 shows that collaborative innovation with research organisations more than triples the likelihood of business productivity growth. Compared to businesses that don't innovate, innovative Australian businesses that collaborate with research organisations (amongst others) are 242% more likely to report increases in productivity (Chart 2.1).

This significant positive influence of collaborative innovation is also evident for other firm performance measures such as export markets targeted, the range of goods and services offered and the provision of staff training (data not shown).¹⁰⁶This effect is less strong for those collaborative innovators that did not have a research organisation as one of their collaboration partners.

Despite the benefits, Australia's overall levels of collaborative business innovation and business-to-research collaboration on innovation continue to compare poorly with other OECD countries (Table 2.1). Relative to other OECD countries, Australia's level of collaborative business innovation is low (ranked 23rd or lower depending on business size). Interestingly, SMEs have caught up with, and even slightly exceeded, large businesses on the levels of collaborative innovation.

102 For example, see *Australian Innovation System reports 2011* (chapter 3) and *2012* (chapter 4).

103 See chapters on collaboration, *Australian Innovation System 2011 and 2012 reports*, www.innovation.gov.au/aisreport.

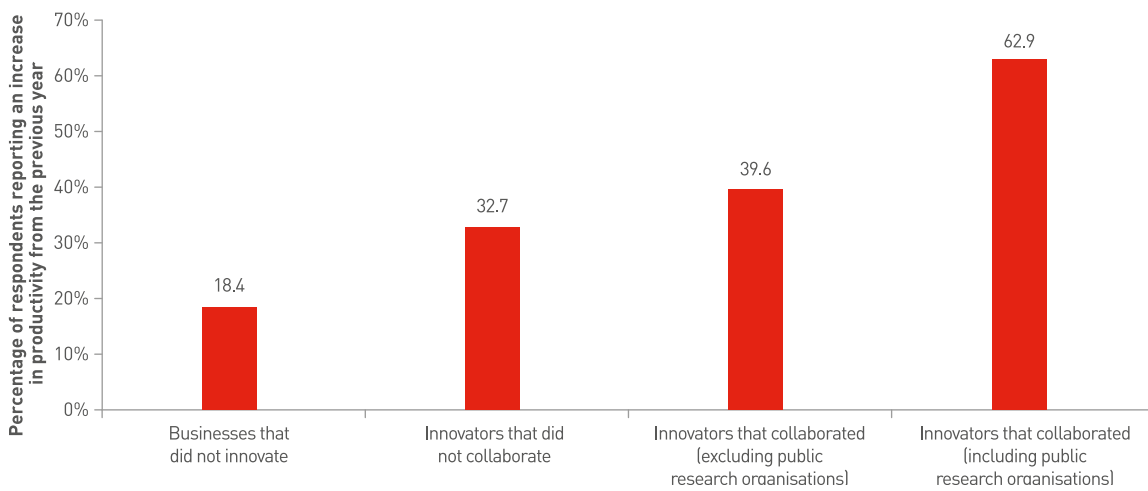
104 Australian Government (2012) *Australian Innovation System Report – 2012*, DIISRTE, Canberra, p.65.

105 See chapters on collaboration, *Australian Innovation System 2011 and 2012 reports*, www.innovation.gov.au/aisreport.

106 The size and levels of significance vary, particularly between collaborative innovators that collaborate with researchers versus those collaborative researchers that don't.

Another, perhaps related, impact of collaboration is on the degree of innovation novelty. An ongoing policy objective is the effective translation of R&D performed by the research sector into commercial outcomes, which is argued as a way to shift more innovative businesses away from incremental ('second-hand') innovation (see also Batterham feature article) towards more world-first innovation. Collaborative innovation is significantly correlated with the introduction of New-to-Australia or world-first innovations.¹⁰⁷ However, relative to other OECD countries, Australia's level of collaborative innovation between industry and research is at or below average, depending on firm size (Table 2.1). This raises a concern that Australia needs to lift its aggregate numbers of innovative, collaborative business above world standards if it is to effectively take advantage of the rapid maturation of other large Asian economies (See Chapter 1).

Chart 2.1 The effect of innovation and collaboration on firm productivity, 2010–11



Source: DIISRTE Custom data request from the ABS (2012) *Innovation in Australian Business 2010–11*, cat. no. 8158.0

The data from Chart 2.1 highlights the importance of not just research organisations but also collaboration on innovation with a broader range of collaboration partners. A more diverse set of collaborators on innovation can give businesses a performance edge. A broader exposure to ideas and information can generate more positive innovation outcomes regardless of innovation type (Chart 2.2). Chart 2.2 allows further refinement of the notion of collaboration by looking at the number of different sources of ideas and information that businesses use when introducing an innovation. Vinding (2006) has found that the more diverse the sources of information and partners are the stronger the innovation performance of a business.¹⁰⁸ We have used Australian data from the ABS Business Characteristics Survey to confirm this result. The resulting data shows a clear positive trend between the proportion of businesses innovating and the number of different sources of ideas or information for innovation. Furthermore, this effect appears to hold for all types of innovation—goods and services; operation processes; organisational and managerial methods; and marketing methods. Process innovation appears to level out at three to four sources (Chart 2.2).

Another indicator of researcher-to-business collaborative innovation is joint patenting activity by publicly funded research organisations (PFROs).¹⁰⁹ The majority of Australian PFRo patents (71%) are not partnered with businesses or others (Chart 2.3). Approximately 15% are with other Australian PFRos, SMEs, independent bodies and state and federal governments. Business-to-research joint patenting accounts for 12% of all joint patenting, with multinationals being a large proportion—at 5.5%.

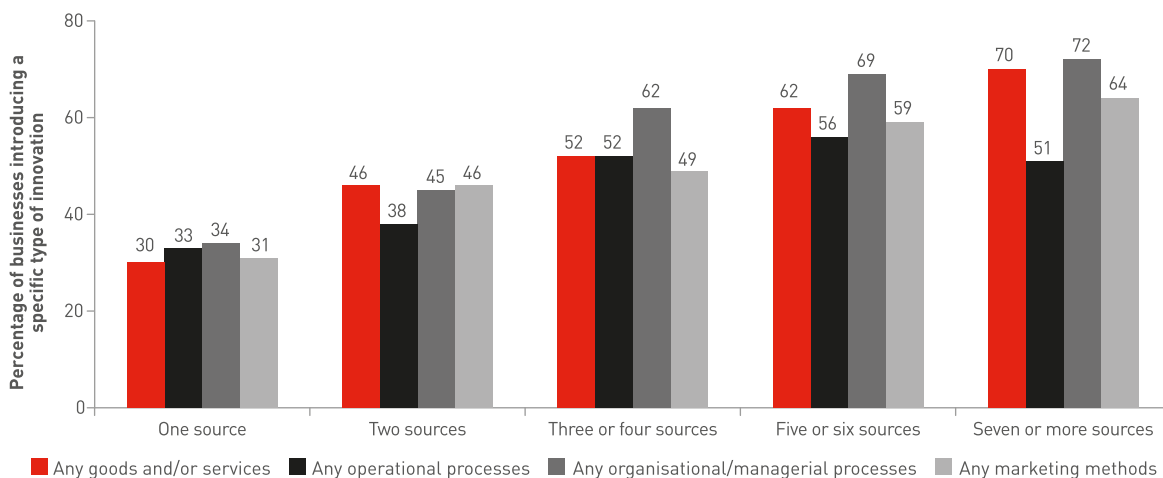
Over one third of Intellectual Property (IP) rights associated with Australian PFRos and their spin out companies are from the pharmaceuticals and biotechnology fields. Examples are patents related to cancer therapy, agriculture biotechnology and immunology, as well as drugs for diabetes, Alzheimer's and inflammatory diseases.

¹⁰⁷ Australian Government (2006) *Collaboration and other factors influencing innovation novelty in Australian businesses: An econometric analysis*, Department of Industry, Tourism and Resources, Canberra, Australia.

¹⁰⁸ Vinding AL (2006) Absorptive capacity and innovative performance: A human capital approach, *Economics of Innovation and New Technology*, 15, 507–517.

¹⁰⁹ As measured by the number of patents coming out of research organizations that have a business also named on the patent (a joint assignee).

Chart 2.2 Innovation type by the number of sources of ideas and information for innovation, 2010–11



Source: DIISRTE Custom data request from the ABS (2012) Innovation in Australian Business 2010–11, cat. no. 8158.0

Interestingly, only 2% of joint patenting by Australian PFROs is with an Asian company, institution or government agency. These patents have Asia as a first filing location of choice (53%). This is different from the rest of the patents, which have Australia as the first filing location of choice (72%), followed by the United States (21%) and Asia (2.4%). These proportions are broadly comparable with the results presented in Chapter 1 on the import of intellectual property between Australia and the rest of the world. Of the total intellectual property service debits (\$3.95 billion), Asia accounts for 10%; the US 44%; and Europe 35%.

Table 2.1 Indicators of Australia's collaboration activity by innovation active businesses

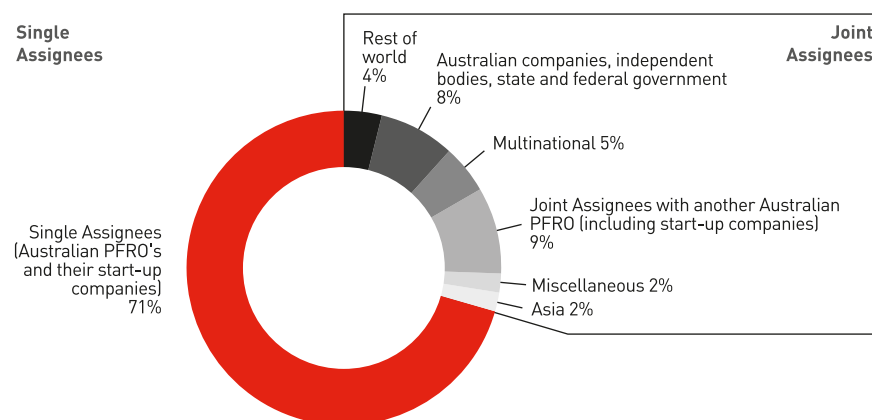
Indicators	Australian trend data ⁽ⁱ⁾										OECD comparison				
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	Australia's score ⁽ⁱⁱ⁾	OECD average ⁽ⁱⁱⁱ⁾	OECD top 5 average ^(iv)	Gap from the top 5 OECD performers ^(v) [%]	Ranking against OECD countries ^(vi)
Proportion of Australian businesses collaborating on innovation [% innovation-active firms] ^{1, (a)}	-	-	-	20.6	-	17.1	-	25.0	-	-	19.1	34	50.1	62	23rd
Proportion of SMEs collaborating on innovation [%] ⁽²⁾	-	-	-	17.7	-	16.9	-	24.9	-	-	16.9	33.6	52.8	68	27th
Proportion of large firms collaborating on innovation [%] ⁽²⁾	-	-	-	23.5	-	23.5	-	24.4	-	-	23.5	56.4	74.2	68	28th
Proportion of innovation-active businesses collaborating for any reason [% of respondents] ⁽³⁾	-	-	-	15.9	20.7	22.5	22.2	22.4	-	-	-	-	-	-	-
Proportion of non-innovation active businesses collaborating for any reason [% of respondents] ⁽⁴⁾	-	-	-	6.4	6.5	7.6	6.7	7.4	-	-	-	-	-	-	-
Proportion of innovation active firms collaborating with universities or other research institutions excluding commercial ⁽⁵⁾	-	-	-	12.1	-	9.5	-	9.6	-	-	-	-	-	-	-
Proportion of innovation active SME firms collaborating with universities or other research institutions excluding commercial [%] ⁽⁵⁾	-	-	-	12.1	-	9.5	-	9.6	-	-	12.7	13	20.5	38	15th
Proportion of innovation active large firms collaborating with universities or other research institutions excluding commercial [%] ⁽⁵⁾	-	-	-	12.7	-	15.8	-	13.7	-	-	20.6	32.9	53.3	61	21st

Sources: [1] OECD (2010) Measuring Innovation: A New Perspective; ABS (2012) special DIISRTE data request, from Innovation in Australian Business, 2008-09 and 2010-11, cat. no. 8158.0. [2] OECD (2009) OECD Science, Technology and Industry Scoreboard 2009; ABS (2012) special DIISRTE data request from Innovation in Australian Business, 2008-09 and 2010-11, cat. no. 8158.0. [3] ABS (various) Selected Characteristics of Australian Business, excludes agriculture, cat. no. 8167.0 and ABS (2012) Innovation in Australian Business, 2010-11, cat. no. 8158.0. [4] ABS (various) Selected Characteristics of Australian Business, excludes agriculture, cat. no. 8167.0. [5] Australian Bureau of Statistics, Innovation in Australian Business, special data request.

Indicator notes: (a) For OECD comparison, the percentage is expressed in terms of % of innovative firms. This excludes those firms that have ongoing and abandoned innovations, which are included in the innovation-active firm population.

Table notes: (i) Data is presented in calendar year format. Where the data is in financial years, it is expressed in terms of the year where the financial year begins e.g. 2010-11 is shown as 2010. (ii) The 'Australia's score' field presents the Australian values used in the OECD comparisons. The Australian values (2008-09) used in the calculation of the gap from the top 5 OECD performers' and the rankings against OECD countries are derived using the OECD business size definitions to ensure comparability between the Australian and OECD data. The OECD business size definitions are different to those that the ABS uses. Consequently, the values in the 'Australia's score' field differ from those presented in the time series under the Australian trend data for the corresponding year. (iii) This is the arithmetic (simple) average of the OECD country scores. (iv) This is the arithmetic (simple) average of the top five OECD countries in a ranked list. (v) This represents Australia's distance from the frontier as defined by the average of the top five ranked OECD countries. It is calculated as 100*(Top five average - Australia's score)/Top 5 average. Where the solution is a negative value or zero, 'no gap' is shown in the cell. (vi) OECD rankings are performed on those OECD countries for which data is available. Individual data availability may vary between indicators. "-" = data not available.

Chart 2.3 Single and joint-assignees on Australian PFROs patents from 2000–2011



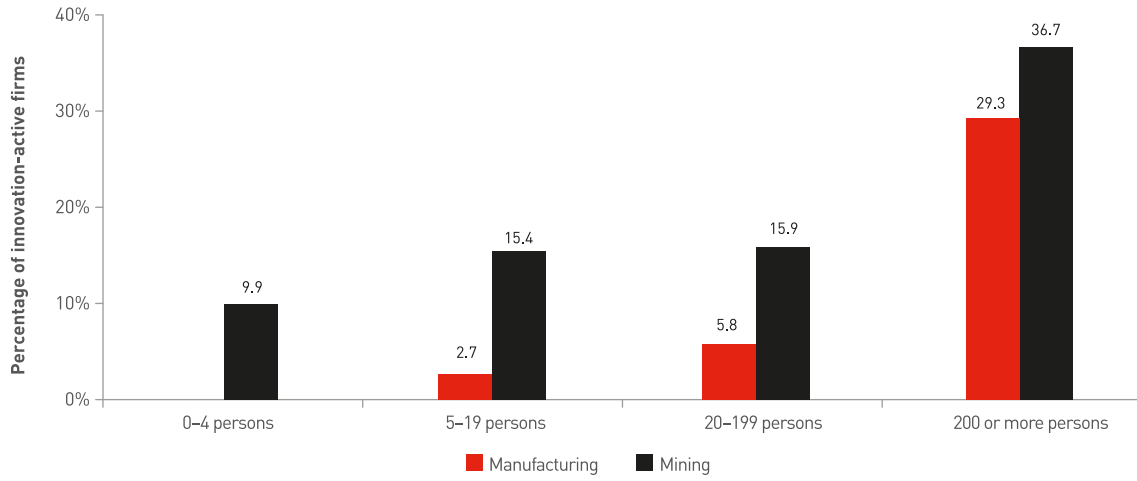
Source: Thomson Reuters special data request.

Data on various forms of collaboration such as joint R&D, joint buying, joint production of goods or services, integration in supply chain and joint marketing or distribution show that large firms are more active collaborators than SMEs (Table 2.1).¹¹⁰ Going deeper, sectoral variations between large and small firm collaboration can be found. The top three sectors undertaking joint R&D were Mining (18.7%), Information Media and Telecommunications (14.4%) and Professional, Scientific and Technical Services (11.7%). Chart 2.4 shows the case of the manufacturing and mining sectors' collaboration on joint R&D. As can be seen, the difference between large firms and small and medium sized firms' collaboration in mining is significantly lower than for manufacturing. One possible explanation has to do with the differences in the types of businesses in these sectors. Manufacturing is a highly diversified sector with a lot of different types of businesses while the mining sector is more uniform. This higher uniformity makes collaboration easier by allowing common goals to reinforce precompetitive, open R&D.

Official data also indicates that the total (including all firm sizes) levels of collaborative innovation are low, as 77.6% of the innovation-active firms and 92.6% of non-innovation active firms have no collaborative arrangements. Percentages of firms undertaking joint R&D are also low: 6.2% for innovation-active and 1.2% for non-innovation active businesses. Yet, this is the collaborative activity where the difference between innovation-active and non-innovation active business is most marked.

Joint production of goods or services and integrated supply chains are important collaborative arrangements in which firms share resources and coordinate activities related to production, services and logistics. In joint production of goods and services, again, Information Media and Telecommunications; Mining; and Professional, Scientific and Technical Services are the industry leaders, with about one in five of the innovation-active businesses undertaking collaboration in this activity. Sectoral differences are less pronounced in supply chain collaboration; however, the retail sector shows higher proportions of innovation-active firms collaborating on this activity.

Chart 2.4 Joint research and development by business size for the Manufacturing and Mining sectors, 2010–11



Source: ABS (2012) *Selected Characteristics of Australian Business, 2010–11*, cat. no. 8167.0.

FEATURE: SECOND-HAND INNOVATION – THE CASE FOR MORE COLLABORATION



By Professor Robin Batterham, Kernot Professor of Engineering, University of Melbourne

There are two somewhat opposed ways one can look at innovation and Asia. The first and most obvious is to look at the growing markets, the incredible demand for commodities and now, with the emerging middle classes in China and India, the demand for products and services. All of this suggests that Australian firms that come up with innovative products and services will do well. So why has the number of Australian firms involved in innovation flat lined for several years around 40%?

Perhaps we have flat lined in innovation despite the growing market opportunities because the perceived risks are just too great or the incentives inadequate. There is of course no innovation without risk. So,

how to spread the risk of innovation and in so doing, still have a worthwhile reward?

Spreading the risk involves collaboration. We have long been admonished to collaborate more, whether firm to firm or firms and researchers. Indeed, our bottom of the OECD performance here well justifies the Chief Scientist's recent recommendation on collaboration as one of his top breakthrough actions for innovation.¹¹¹

Collaboration can be anywhere along the chain that results in innovation (a new product standing in the market place). It can be early on at the technology end, at the production stage or in the market. The point with tackling any of these steps with others is that it not only spreads the financial risk but more importantly, it opens up the networks of each partner to the other. The Australian Innovation System Report has consistently shown that the sources for ideas come largely from outside of the companies undertaking innovation. What Australian firm might make money out of applying the protocol developed by IBM in India for navigation through hypermedia via speech?¹¹² How might they collaborate?

This notion of collaborating with those that are already innovating I call "second-hand innovation". It is not to imply inferiority, simply that in the first instance, the innovation is already happening elsewhere. And there are many targets for Australia but two stand out: China and India.

China is a stand out target for collaboration as they are so strategic, so well-resourced when it comes to targeted science and technology support for innovation and, of course, the market drivers have many similarities with Australia. The mutual appreciation of cultures tends to work to our advantage. Chinese S&T deserves particular mention. In many fields, consistent investment by combinations of Government and companies has led to world class support structures. Look at the Chinese Academy of Sciences and their Process Engineering effort in understanding the fine details of how one can connect fundamental understanding at the micro scale with real world performance at operational scale. This is key to de-risking large first of a kind process plants. For power stations, it is now hard to go past the performance, quality and price of companies from China.

When it comes to industrial R&D to support innovation, many Chinese companies excel. Co-investment by state owned enterprises and directed by government is a familiar model, as is targeting world class people to run these ventures. The National Institute of Clean and Low Carbon Energy in Beijing, supported by Shenhua Coal is a stand out example.¹¹³ Finding ways to collaborate with such ventures makes sense, perhaps through common links to Universities or those already collaborating, such as Tsinghua and Melbourne Universities.

111 Office of the Chief Scientist (2012) *Top Breakthrough Actions for Innovation*, December 2012, Prime Minister's Science Engineering and Innovation Council, Canberra.

112 <https://www.research.ibm.com/irl/spokenweb2.html>.

113 National Institute of Clean and Low Carbon Energy (NICE). <http://www.nicenergy.com>.





India too has some special opportunities for collaboration. My own experience with the Australia India Strategic Research Fund has highlighted not just the benefits of good collaborative research, but more importantly, how developing institutional arrangements are resulting in collaboration between S&T providers in both countries with companies in Australia. Watch this space in the dairy industry and in wheat and enhanced foodstuffs as examples. The benefits of the Monash University IIT, the Deakin University TERI and the RMIT University IICT links will proliferate in years to come.

When one looks at how the number of institutional collaborations is growing exponentially,¹¹⁴ there is a matter of timing to consider. Australia has to be energetic before the relationships of China and India become more locked in to other countries. Familiarity breeds familiarity!

Finally, there is the question of incentives: how to raise the performance of the 60% of firms in Australia that don't innovate. Exposure at every level to opportunities to collaborate, particularly with Asian countries, needs to be a priority. Can we be more generous with our existing schemes that support visits, workshops and trade missions? Can our schemes that target collaboration such as the ARC Linkages and the new focus on Precincts be opened up somewhat to investment and collaboration with international partners? Should our taxation incentives for R&D (a useful but not the only precursor of innovation) be fundamentally rejigged to target innovation per se, with double incentive for innovation involving collaboration?

Consider in all of this, "second-hand innovation". We don't have to be first in the world, simply first to corner a good market.

¹¹⁴ OECD (2010) *Measuring Innovation: A New Perspective*, OECD Publishing, p.30.

Business innovation and entrepreneurship

Table 2.2 shows Australia's level of innovation activity in terms of R&D expenditure, the proportion of innovation-active businesses, entrepreneurship and patenting, among others. The proportion of innovation-active businesses has shown a relatively stable oscillating pattern since 2005–06. In 2011–12 Australia reached its highest percentage of businesses innovating—at 46.6%. This was driven by increases in more non-technological innovation (organisational and marketing methods) and more micro-sized and small businesses innovating. There is a direct correlation between business size and innovation: the larger the business, the higher its level of innovation activity. When looking at the proportion of innovation-active business by innovation type, the trend is broadly in the following order: organisational/managerial innovation > goods or services innovation > marketing innovation ≈ process innovation (Table 2.2).

A measure of investment in innovation is the capital stock of intangible investment (defined as investment in R&D, computer software, artistic originals, and mineral and petroleum exploration).¹¹⁵ The levels of intangible investment have more than doubled since 1995—from \$118 billion to \$250 billion in 2010. BERD as a share of GDP has shown remarkable growth, almost doubling since 2000, having grown from 0.70% to 1.38% in 2008, before declining to 1.27% in 2010. Reflecting the changing environment of business R&D, this shift was accompanied by a halving of government-financed BERD as a share of GDP. Broadly, direct government funding of business R&D was replaced by assistance through the tax system, with the number of businesses registered for the R&D tax concession more than doubling.

Australia performs well in conditions supporting entrepreneurship and the dynamics of entrepreneurs. Australia's rates of entrepreneurship are ranked in the OECD top five. Several other countries in the top five such as Mexico have a much higher proportion of necessity-driven entrepreneurs compared with those driven by opportunity. Barriers to entrepreneurship are low and the cost of starting a business has fallen since 2006. Australia still ranks very well and consistently as one of the countries with the lowest number of procedures to start a business. A recent report from PwC indicates that Australia already has one of the most favourable environments for entrepreneurship and the support for people interested in becoming entrepreneurs is high.¹¹⁶ Australians in general have lower entrepreneurial interest compared with other countries such as the Netherlands, Italy, Portugal and France; only 54% of the Australian adult population consider entrepreneurship to be an interesting career path.¹¹⁷ The largest barrier to Australian entrepreneurship appears to be barriers to competition. However, from those who are interested in becoming entrepreneurs, 19% will plan to start a business in the next three years ('entrepreneurial intention') and the same proportion will actually embark on the entrepreneurial journey over the same period. These percentages are among the highest in the developed world and show that Australians are more likely to become entrepreneurs than people in any other innovation-driven economies.¹¹⁸

The PwC report focuses on 'tech start ups' which they defined as businesses where:

- Technology is central to the product/service being provided.
- High leverage of labour input to their products/services so that the business can scale rapidly.
- The product/service is a disruptive innovation in that it helps create a new market or new supply chain/network which disrupts an existing market.
- Revenue is under \$5 million per annum.

¹¹⁵ For the definition of intangible investment, refer to the notes and sources corresponding to the intangible capital stock indicator in Table 2.2.

¹¹⁶ PwC (2013) *The start-up economy: How to support tech start-ups and accelerate Australian innovation*, Report commissioned by Google Australia, PwC, Melbourne.

¹¹⁷ *Ibid.* p.18.

¹¹⁸ *Ibid.* p.18.

This category of businesses makes up a relatively small proportion of all start-ups but is receiving considerable policy attention globally because of their potential for rapid growth. The PwC report estimated that there were around 1,500 tech start-ups ranging from one or two person start-ups created in the last 12 months to more established businesses that have been around for a decade. The start-up sector is concentrated in ICT, with 29% of the founders of technology start-ups having computer science backgrounds.¹¹⁹ The PwC report also points out that there are good opportunities for start-ups in industries such as finance and insurance and manufacturing. The health care and social assistance industry will provide important markets for technology start-ups as this sector has been predicted to increase significantly its contribution to GDP by 2050. Start-ups are well placed to drive productivity growth throughout the economy by the application of new technology to existing industry. This will reduce both (per unit) labour and capital inputs required to produce goods and services.¹²⁰

Intellectual property indicators show a mixed story. While the number of intellectual property outputs has been rising; in terms of per head of population, there has been a strong downtrend since 1995. This includes triadic patents, PCT patents and industrial designs; the exception being trademark registrations, which have remained stable. In terms of the share of patents, there has been a reduction in the share of triadic patent families, but this was matched by a strong rise in the share of PCT patents filed (Table 2.2).

Large Australian businesses rank towards the bottom of the OECD in innovation at 26th out of 28 OECD countries (Table 2.2). Chapter 1 shows that large business is responsible for the majority of exports. Taken together it is a matter of concern that large firms are responsible for the majority of export value and yet represent a sector of the economy with relatively poor innovation performance. Although better data is needed to contrast innovation frequency and impact, this result has implications for Australia's ability to capture rapidly maturing Asian markets with innovative goods and services. In contrast, total SME innovation is in the middle range of the OECD—at 16th out of 28 OECD countries (Table 2.2). Notwithstanding comparability issues in terms of the impact of innovation or frequency of reporting (which are not measured), Australian SMEs seem to perform better on innovation than large Australian businesses when placed in an international context.

Previous reports and this year's compendium show that each sector of the economy has its own challenges and different levels of innovation performance. To place these results into context, Australia's innovation activity is compared with a range of EU countries (Table 2.3). Table 2.3 provides a snapshot of Australia's innovation levels by industry sector according to the OECD business size categories and the corresponding share of gross value added in 2010. It also includes the corresponding EU averages for those industry sectors where data was available. Given the distribution of Australia's business population towards micro-sized (0–4 employees), Table 2.3 excludes over 85% of the total number of economically active businesses.¹²¹ The result is that the average percentage of innovation-active Australian businesses is higher in this analysis (at 52.5%) compared with the data presented in Table 2.2 (at 46.6%).

119 *Ibid.* p.20.

120 *Ibid.* p.9.

121 ABS (2013) *Counts of Australian Businesses*, including Entries and Exits, June 2008 to Jun 2012, cat. no. 8165.0. *Note:* The latest estimates of the business population by the ABS show that there are over 2.1 million economically active businesses in Australia. Of this, 85% are in the micro-size (0–4 employees) category.

Table 2.2 Indicators of Australia's innovation and entrepreneurship activity

Indicators	Australian trend data ⁽ⁱ⁾										OECD comparison				
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	Australia's score ⁽ⁱⁱ⁾	OECD average ⁽ⁱⁱⁱ⁾	OECD top 5 average ^(iv)	Gap from the top 5 OECD performers ^(v)	Ranking against OECD countries ^(vi)
BERD as % of GDP ¹	0.82	0.7	1.05	1.17	1.28	1.38	1.30	1.28	-	-	1.28	1.58	2.75	53	13th
Proportion of BERD financed by government ¹	2.4	3.8	4.03	3.86	2.81	2.02	2.02	1.81	-	-	1.81	8.10	15.00	88	25th
Number of businesses registered for the R&D Tax Concession ^{2, (a)}	3,734	3,732	6,421	6,967	7,910	8,575	8,756	9,277	10,286	-	-	-	-	-	-
Intangible capital stock (\$billion) ^{3, (b)}	118	157	197	208	220	231	240	250	-	-	-	-	-	-	-
Proportion of innovation-active businesses in Australia ⁴	-	-	42.4	37.1	44.9	39.8	43.8	39.1	46.6	-	-	-	-	-	-
Proportion of innovation-active SMEs (0-199 persons) ⁵	-	-	-	36.7	44.8	39.7	43.7	38.9	46.5	-	48.9	51.5	72.4	32	16th
Proportion of innovation-active large firms (200 or more persons) ⁴	-	-	76.5	66.2	70.8	66.7	74.3	65.9	76.0	-	62.9	78	91	31	26th
Proportion of businesses introducing goods or services innovation ⁶	-	-	19.3	18.4	21.9	18.2	19.8	17.3	20.4	-	-	-	-	-	-
Proportion of businesses introducing operational/ process innovation ⁶	-	-	20.8	17	17.6	16.3	16.9	16.4	19.1	-	-	-	-	-	-
Proportion of businesses introducing organisational/managerial process innovation ⁶	-	-	20.7	16.5	19	19.4	20.7	18.9	23	-	-	-	-	-	-
Proportion of businesses introducing marketing innovation ⁶	-	-	14.3	12.9	14.6	17.2	16.7	16.8	19.9	-	-	-	-	-	-
Share of high and medium high technology manufacturing as a percentage of GDP ⁷	-	-	-	2.64	2.60	2.26	2.30	2.18	2.19	-	-	-	-	-	-
Firm entry rate (%) ^{8, (c)}	-	-	16.3	17.1	15.3	14.4	16.7	13.9	13.5	-	15.7	10.3	15.5	No gap	2nd
Firm death rate (%) ^{8, (d)}	-	-	15.0	14.6	15.3	15.4	13.1	13.5	13.1	-	13.1	10.2	5.9	123	15th
Churn rate (%) ^{8, (e)}	-	-	1.3	2.5	-0.1	-1.0	3.6	0.4	0.4	-	29.5	20.7	27.9	No gap	2nd
Firm survival rates (annual), (%) ^{8, (f)}	-	-	85.0	85.4	84.7	84.6	86.9	86.5	86.9	-	62.8	53.8	62.9	0	3rd
Patents granted by IP Australia, for Australian residents ^{9, (g)}	-	-	-	924	1,086	925	926	1,178	1,262	1,311	-	-	-	-	-
Innovation Patents by AU residents ^{9, (h)}	-	-	926	918	1,034	1,028	1,109	1,127	1,204	1,205	-	-	-	-	-

Indicators	Australian trend data ⁽ⁱ⁾										OECD comparison				
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	Australia's score ⁽ⁱⁱ⁾	OECD average ⁽ⁱⁱⁱ⁾	OECD top 5 average ^(iv)	Gap from the top 5 OECD performers ^(v)	Ranking against OECD countries ^(vi)
Industrial designs certified by IP Australia, for Australian residents ^{9, (i)}	-	-	115	151	238	342	274	327	265	318	-	-	-	-	-
Triadic patent families per million population ¹	13.0	19.7	13.8	12.0	11.5	10.8	10.1	9.8	9.3	-	9.3	24.4	76.9	88	20th
Patent applications filed by AU residents under PCT per million population ^{9, (i)}	-	-	-	95.7	96.9	89.6	78.6	78.9	76.8	75	-	-	-	-	-
Industrial design registrations (AU resident) per million population ^{9, (k)}	121	98	136	168	110	113	119	111	111	107	-	-	-	-	-
Trade Mark applications from Australian residents ⁹	19,036	27,175	38,193	40,538	40,001	38,381	38,466	39,633	40,056	41,106	-	-	-	-	-
Trademark registrations (AU resident) per million population ^{9, (k)}	429	504	1,091	1,120	1,221	1,245	1,123	1,077	1,062	10,063	-	-	-	-	-
Share of world triadic patent families (%) ¹	0.7	0.8	0.6	0.6	0.6	0.6	0.6	0.5	0.49	-	0.49	2.8	16.1	97	17th
Share of world patent applications filed under PCT (%) ¹	4.6.2	91.1	101.9	98.4	94.5	84.2	84.0	77.8	73.5	-	73.5	109.5	287.3	74	19th
Total early-stage entrepreneurship activity (TEA) (%) ^{10, (l)}	-	14.7	10.5	11.9	-	-	-	7.8	10.5	-	10.5	8.19	14.52	28	5th

Source: [1] OECD MSTI, *Main Science and Technology Indicators database*, 2013/1. [2] Innovation Australia Annual Report 2011-12 and DIICSRTE unpublished data. [3] ABS (2012) *Australian System of National Accounts*, cat. no. 5204.0; Melbourne Institute of Applied Economic and Social Research (2012) *Figures commissioned by DIISRTE*. [4] ABS (various) *Summary of IT Use and Innovation in Australian Businesses*, cat. no. 8166.0 and OECD (2011) *Science, Technology and Industry Scoreboard 2011* for the OECD data. [5] ABS special data request and OECD (2011) *Science, Technology and Industry Scoreboard 2011* for the OECD data. [6] ABS (various) *Selected Characteristics of Australian Businesses*, cat. no. 8167.0. [7] ABS (various) *Experimental Estimates for the Manufacturing Industry*, cat. no. 8159.0 and ABS (2012) *Australian System of National Accounts 2011-12*, cat. no. 5204.0. [8] ABS (various), *Counts of Aust Businesses including entries and exits*, cat. no. 8165.0 and OECD *Entrepreneurship at a Glance 2013* for OECD data. [9] IP Australia special data request. [10] Global Entrepreneurship Monitor: Adult Population Survey (various).

Indicator notes: (a) This indicator corresponds to the number of entities registering R&D expenditure with AusIndustry in order to claim the tax incentive or tax concession through their annual tax returns. Number of entities includes R&D performing subsidiaries of head companies registered under the R&D Tax Incentive. The registered R&D is reported against the income year in which it is registered. This is the year following the year in which the companies undertake the R&D activity. The data for the 2011-12 income year are as at 30 June 2013 and are incomplete; further applications for the 2011-12 income year will continue to be received up to 31 October 2013 from companies with non-standard income period balance dates. (b) Intangible capital investment includes R&D, Design, Market research & Branding, Organisational improvement, Business-specific training and skills development, Software development, Mineral exploration and Artistic originals. (c) Firm entry rate (%) = 100 x Entries/Number of businesses operating at the start of the financial year. A business entry event is the registration of a new business for an ABN and the allocation of a GST role, or the allocation of a GST role to an existing ABN which previously did not have this role. (d) Churn rate (%) = 100 x (Entries - Exits)/Number of businesses operating at the start of the financial year. A business exit event is the cancellation of a business' ABN or GST role and/or when a business ceases to remit GST for at least five consecutive quarters in respect of that ABN for 3 consecutive years (or annual remitters). Thus, a business exit is defined as a business which was actively trading on the business register at 30 June in the previous year but was not actively trading at 30 June in the reference year. (e) Death rate (%) = 100 x Exits/Number of businesses operating at the start of the financial year. (f) Survival rate (%) = 100 - Death rate (%). (g) IP Australia's databases country codes are not complete for mainframe applications. As a result, the number of Australian grants may be understated prior to 2008. (h) The innovation patent regime was established in November 2000, and as such the first full year of data available is 2001. (i) Design Certification was introduced with the 2003 act, so no observations before then. (j) PCT data is not currently available prior to 2006. (k) The population data has been sourced from ABS (2013), Australian Demographic Statistics, Dec 2012, Cat. no. 3101.0. (l) TEA (%) is defined as the percentage of 18-64 age group who are either a nascent entrepreneur or owner-manager of a new business. A nascent entrepreneur is one that is actively involved in setting up a business they will own or co-own; this business has not paid salaries, wages or any other payments to the owners for more than three months. The owner-manager of a new business is defined as one that has paid salaries, wages or any other payments to the owners for more than three months, but not more than 42 months.

Table 2.3 Percentage of innovation-active businesses by industry sector and the corresponding gross value added (GVA), 2010–11—Australia and EU for selected industry sectors

Industry sectors	Percentage of innovation active businesses (and Australia's rank against the EU) ^[1]		GVA at current prices (\$million), 2011-12 ^[2]	Industry share of GVA (%) at basic prices, 2011-12 ^[2]
	Australia (2010)	EU average (2010)		
Financial and Insurance Services	74.3 (4 th /32)	56.9	144,850	10.5
Wholesale Trade	70.9	-	63,548	4.6
Information Media and Telecommunications ^[a]	70.4 (8 th /24)	59.2	41,776	3
Manufacturing ^[b]	70.2 (2 nd /31)	51.3	105,111	7.6
Professional, Scientific and Technical Services ^[c]	69.4 (3 rd /24)	46.2	97,539	7.1
Health Care and Social Assistance	63.7	-	87,114	6.3
Electricity, Gas, Water and Waste Services	62.9	-	35,573	2.6
Retail Trade	56.9	-	65,595	4.8
Construction	56.2	-	106,496	7.7
Other Services	55.1	-	25,124	1.8
Arts and Recreation Services	54.8	-	11,864	0.9
Mining ^[d]	52.8	38.5	142,231	10.3
Administrative and Support Services	51.3	-	35,313	2.6
Rental, Hiring and Real Estate Services	49.9	-	32,159	2.3
Agriculture, Forestry and Fishing	45.7	-	32,545	2.4
Accommodation and Food Services	43.7	-	34,498	2.5
Transport, Postal and Warehousing ^[e]	43.0 (7 th /30)	35.7	69,751	5.1
Proportion of innovation-active businesses	52.5 (8 th /32)	52.9	-	-
All industries - GVA at current prices	-	-	1,299,285.00	-

Source: [1] ABS special data request for Australian data and Eurostat (online data code: inn_cis7_type) for EU data. [2] ABS (2012) *Australian System of National Accounts, 2011-12*, cat. no. 5204.0.

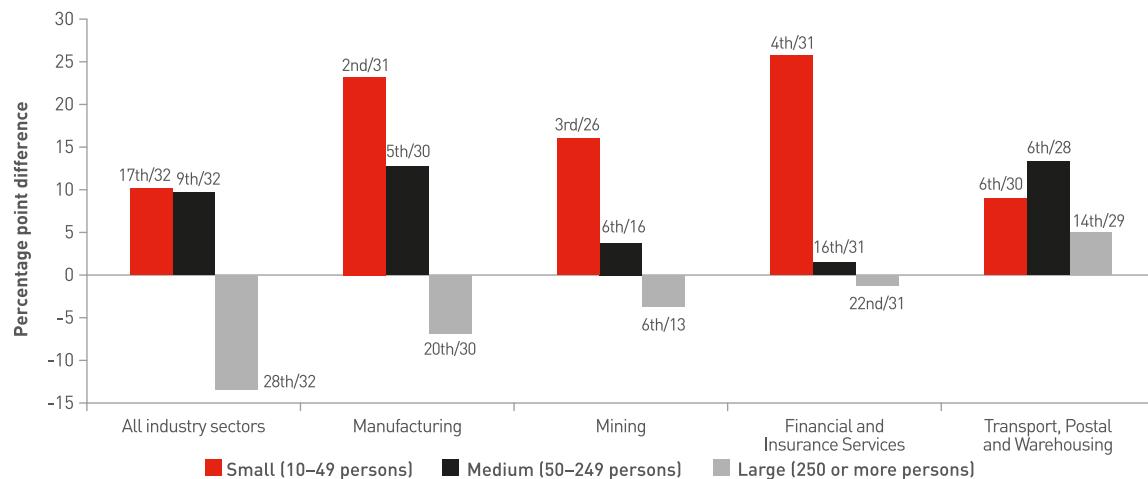
Indicator notes: For the EU countries, some industry sectors had low rates of reporting by member countries and were not suitable for comparison. (a) Data not available for Germany, Estonia, Ireland, Luxembourg, Austria, Finland, UK, Turkey. (b) Data not available for Slovenia. (c) Data not available for Germany, Estonia, Ireland, Luxembourg, Austria, Finland, UK, Turkey. (d) Data not available for Slovenia. (e) Data not available for Lithuania and Slovenia.

Table notes: “-” = not available.

Table 2.3 shows that Australian businesses are relatively well-ranked (8th out of 32 countries) compared with their EU counterparts. This result for Australia appears at first glance to be much better than the international comparison made in the previous report;¹²² however, the data in Table 2.3 excludes five other higher performing OECD countries present in the last report. The next edition of the OECD STI Scoreboard (due on 21 October 2013) will provide a broader comparison.

We know from previous reports that the proportion of innovation-active businesses also varies considerably with business size. It is therefore important to compare country innovation performance by both size and sector to account for structural differences. Chart 2.5 compares Australia's innovation performance with EU countries for selected sectors and business size classes. It does this by looking at the percentage point difference between the EU average and the Australian average for a particular sector. Innovation in large business is below the EU average for the majority of sectors analysed and is consistently lower than the small and medium sized businesses. This data is of concern, given that large businesses are the drivers of exports and perform the majority of business research and development, yet show comparatively poor innovation performance relative to other OECD countries.¹²³ The data suggests potential inefficiencies (see Introduction and Chapter 5) in the innovation system or, at least, very different strategic intent behind large firm investments in innovation.

Chart 2.5 A comparison of Australia with the EU average across selected industry sectors and business sizes



Source: Eurostat (online data code: inn_cis7_type) for EU data and ABS (2012) *Innovation in Australian Business, 2010-11*, cat. no. 8158.0 for Australian data.

Notes: The rankings above the bars correspond to Australia's rank against the EU countries.

122 Australian Government (2012) *Australian Innovation System Report - 2012*, DIISRTE, Canberra, p.53.

123 ABS (2012) *Research and Experimental Development, Businesses, Australia, 2010-11*, cat. no. 8104.0. Note: In 2010-11, large business performed 68% of total business expenditure on R&D (BERD).

FEATURE: MAINSTREAM DESIGN AS AN INNOVATION DRIVER

By Distinguished Professor Stuart Cunningham, Director, ARC Centre of Excellence for Creative Industries and Innovation.

An examination of worldwide trends in bringing policies supporting innovation and creative industries closer together shows that, along with digital content, design is the sector and activity that leads the way.¹²⁴ Design is being mainstreamed into much industry, workforce and policy thinking. George Cox's influential *Review of Creativity in Business*¹²⁵ in 2005 for the UK government positioned design, when it is thought of as a distinct sector, as a bridge between the arts and engineering sciences (the aesthetic-expressive and technical-rational modes of knowing) and a link between research and enterprise in the innovation chain (when design is thought of as method or mindset that links research into new ideas on the one hand and the development of practical applications on the other).

In the first, design is inserted into the science-engineering-technology model of innovation as the bridging sector between scientific research and consumed technology. This occurred first and foremost in the field of industrial design and the place most famous for it was Finland. In the mid-1990s, the Helsinki University of Art and Design, with the Finnish government, identified design as a critical sub-system within the national innovation system. At the turn of the century, the Design 2005 strategy¹²⁶ focused on industrial design, but over time all design fields have come to be included.

Design also has inserted itself into the business model of innovation as the bridging process between business ideas and the successful rollout of innovations. Here the key concept is *design integration*, which means bringing designers into the business processes of firms, as well as bringing design thinking to bear on all of a firm's activities (spruiked by business-design-management gurus – similar to the idea that businesses should be more creative). There are now a wealth of sources, such as the World Economic Forum's Global Competitiveness Report and the UK Design Council,¹²⁷ which have demonstrated that there is a distinct correlation between design-intensity in enterprise activity and product development, and broad economic competitiveness at the firm and national level. As one recent State Government of Victoria report¹²⁸ claimed: 'Design can add value across all aspects of a business, including production processes, branding and communications, leadership, and company culture'. Indeed, the 'input value' of design has spilled over even further, into cutting-edge research and educational practice in business studies. 'Design thinking' is the idea that the mindset, habitus, or skill sets of designers are valuable inputs into contemporary business thinking.

This has given rise to a series of initiatives to better embed design as a driver of innovation into the manufacturing and service sectors. They are demand-side programs; they typically focus on working with companies outside the creative industries to identify how design can address their business needs. This highlights how this approach to design – as a driver of process and organisational innovation differs markedly from the usual understanding of design as product innovation. Global leaders include 'Better by Design', a specialist group within the New Zealand economic development agency, Trade and Enterprise, which has run successfully since 2003 and has hard evidence for significant improvements in export success, design integration and industry support. 'Designing Demand' emerged as a national program as a result of the Cox Review and 'helps businesses with an appetite for growth discover how to become more innovative, more competitive and more profitable'. Management teams are led through a practical-based process

124 Cunningham S (2013) *Hidden Innovation: Policy, Industry and the Creative Sector* (Chapter 1), University of Queensland Press, Brisbane.

125 Cox G (2005) *Cox Review of Creativity in Business: Building on UK's Strengths*, HM Treasury, London.

126 TEKES (2000), *Design 2005! The Industrial Design Technology Programme*, Strategy document for TEKES, TEKES – the Finnish agency for technology and innovation, Helsinki.

127 UK Department of Trade and Industry (DTI) (2005) *Creativity, Design and Business Performance*, DTI Economics Paper No. 15, DTI, London; Paul Cunningham, National and regional policies for design, creativity and user-driven innovation, Thematic Report, Manchester Institute of Innovation Research, University of Manchester, 2008.

128 State Government of Victoria (2010), *Victorian Design Action Plan, 2011–2015*, Department of Innovation, Industry and Regional Development, Melbourne, accessible at http://www.dbi.vic.gov.au/_data/assets/pdf_file/0015/223431/DIIRD-Design-Plan.pdf, p.6.





that helps them to understand how design, used well, can be a strategic and effective tool to boost performance, open new markets, cut costs and reduce risk.¹²⁹

In Australia, state governments have a history of design policy development. Victoria has linked design to state economic performance for almost a decade. Similarly, Queensland's Ulysses design integration program (now a commercial product called Velocis™) focuses on helping mainstream businesses to apply design to build wealth and increase their international competitiveness. The key industry player in this initiative was not a design association but QMI Solutions, a business improvement and innovation unit serving the manufacturing and related industry sectors. Queensland also had HEAT Architecture, the purpose of which was to build an international profile and thus exports for Queensland's architectural and design services and provided business skilling opportunities to help architects break into international markets.

Architecture is, in fact, one of the few creative industries with consistent and growing export-positive performance. (The 2011–12 ABS data show a \$40+ million credit ledger for architectural services. This may significantly undercount the revenues generated by subsidiaries of Australian firms overseas.) Many of Australia's leading architecture and design businesses, including Woods Bagot, Peddle Thorp, Hassell, and HBO, have a consolidated presence in Asia.¹³⁰ Hassell, for example, has been committed to the region since 1991, when it opened a Hong Kong studio. With expertise in architecture, interior design, urban planning and landscape architecture, it is now claimed to be the largest foreign multidisciplinary design practice in China. Its experience in Asia has enabled the broader business to increase the scale and depth of expertise, the cross-fertilisation of ideas and cultural understanding, and broadened the horizons of its staff.¹³¹

The research challenge

Australia lags its OECD confreres in design research, development and policy. Design activity is notoriously underestimated in official national statistics, and employed designers are so broadly embedded throughout industry sectors that their contributions can be significantly undercounted. Design has been conspicuously absent from national policy attention since its excision from the purview of the Australia Council in the 1980s. It is now coming back into focus, with the government's *Australia in the Asian Century* white paper and *A Plan for Australian Jobs: The Australian Government's Industry and Innovation Statement* both peppered liberally with references to design as a key factor in economic performance, export success and innovation. If Australia is determined about design as an innovation driver across the economy, it will need a significantly upgraded attention to research and development, and particularly to methodologies that capture the input value of design in modern 'experience' economies.

129 <http://www.designcouncil.org.uk/designingdemand>.

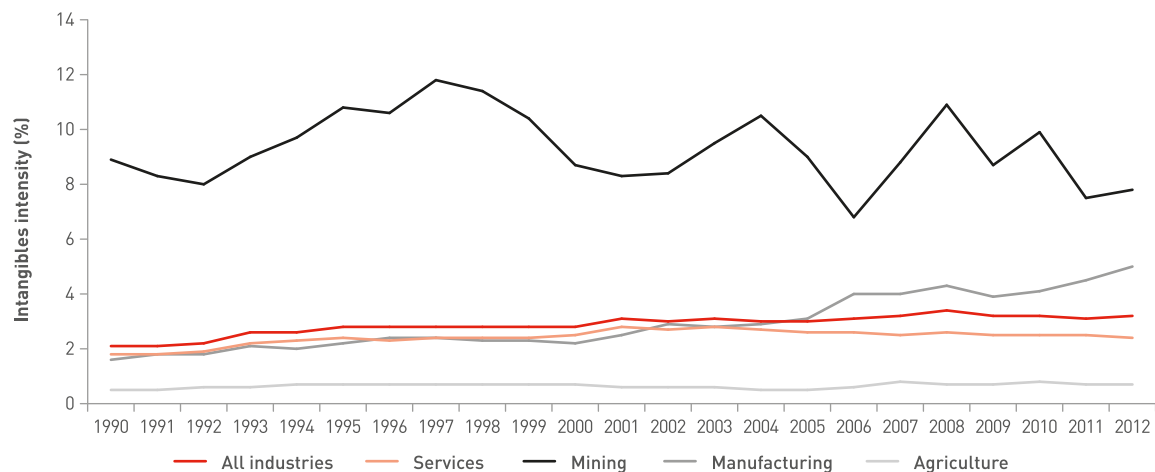
130 <http://www.architectureanddesign.com.au/news/australian-architects-finding-place-in> and <http://international.architecture.com.au/australian-architects-take-on-the-world/>.

131 These insights are drawn from Boston Consulting Group, *Imagining Australia in the Asian Century: How Australian Businesses are Capturing the Asian Opportunity*, September 2012.

Intangible capital investment

Intangible capital intensity is an indicator of investment in innovation and a re-orientation towards a knowledge-based economy.¹³² Chart 2.6 below shows changes in the ratio of intangible assets to value added (intangible capital intensity) by industry sector in the last two decades. Intangible assets include, for most sectors, investments in research and development and computer software. Mining intangible assets also include mineral exploration that represents the largest intangible investment item in this sector; and the arts and recreation sector also includes artistic originals.¹³³ Chart 2.6 shows that the level and rate of growth of intangible capital intensity vary considerably between industry sectors. Total (all industries) intangible capital intensity registered a moderate annual rate of growth of 1.9% between 1990 and 2012. Manufacturing (at 5.5%) and electricity, gas, water and waste services (4.8%) led the growth over this period. In the case of manufacturing, the increase of intangibles intensity has not been at the expense of a fall in value added; indeed, value added has registered growth in real terms since 1990. This suggests that, in spite of the loss of employment in the sector, structural change has been forcing this sector to invest more in innovation. Charts 2.7 and 2.8 show that two types of intangibles—R&D expenditure and software—show large and sustained increases.

Chart 2.6 Intangibles intensity by sector – 1990–2012 (investment in intangibles industry sector value added)



Source: ABS (2012) Australian System of National Accounts, 2011–12, cat. no. 5204.0.

Mining shows the highest level of intangible intensity (Chart 2.6). This is mainly due to large investments in mineral exploration. The rate of mining sector intangible intensity shows a bumpy pattern with a slight declining trend since the late 1990s. However, this is due to a very large increase in value added that has not been matched by investment in intangibles, even though the three types of investment intangibles—mining exploration, R&D and software—have grown at a fast rate (at a compound annual rate of 8.5%, 10.1% and 12.4% respectively between 1990 and 2012).

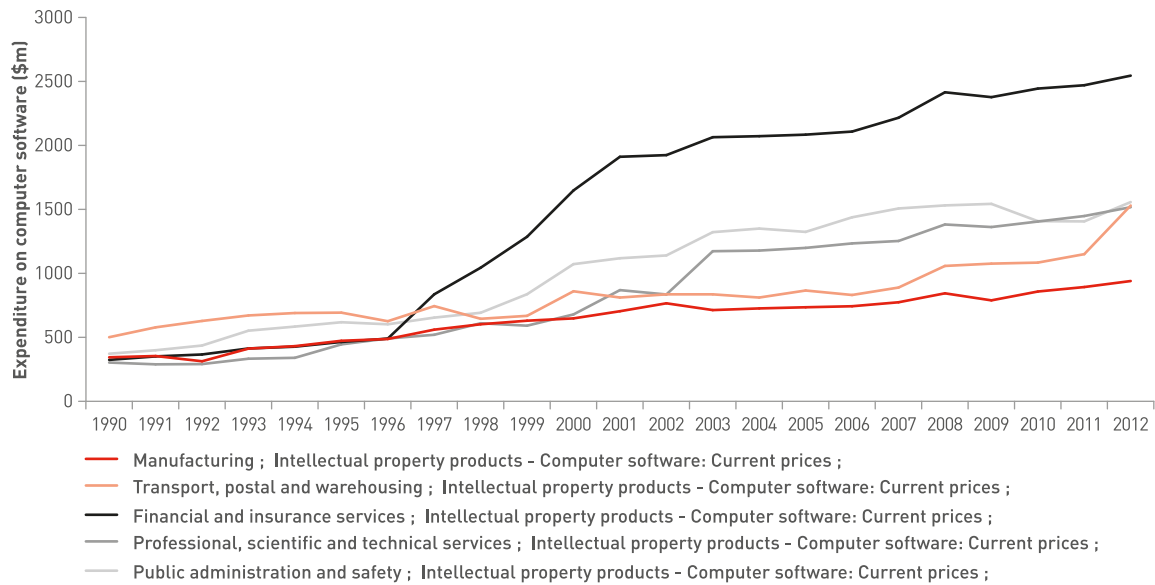
More disaggregated data from Chart 2.8 indicates that the financial services sector has been leading investments in software development since the late 1990s. Interestingly R&D in this sector increased dramatically since the mid-2000s. The lag between the investment in these two types of intangible assets—software and R&D—may suggest that significant R&D effort was dedicated to improving and adapting software systems. There is evidence that this sector is very active in the development of in-house software. Despite the fact that it is large financial and insurance businesses that are investing in the majority of R&D¹³⁴ it is the small businesses that are highly ranked on innovation internationally (Chart 2.5).

132 Analysis from the *Australian Innovation System Report – 2012* suggested that Australia was lagging behind other countries in this shift to a knowledge economy by looking at the balance between investment in physical capital e.g. machinery and equipment, versus intangible capital e.g. R&D (refer to previous Australian Innovation System 2011 and 2012 reports).

133 This classification of assets is taken from the Australian System of National Accounts. The definition used in *Australian Innovation System Report – 2012* is much broader and includes other types of intangible assets such as economic competences. This data, however, is not available at industry sector level.

134 Australian Government (2011) *Australian Innovation System Report – 2011*, DIISR, Canberra, p.60.

Chart 2.7 Investment in computer software in selected sectors (\$ million)



Source: ABS (2012) Australian System of National Accounts, 2011–12, cat. no. 5204.0.

As indicated in Table 2.2 BERD as a percentage of GDP decreased to 1.28% in 2010–11 from 1.30% in 2009–10. This is due to strong growth in Australia’s current price GDP of 8.3% over the same period. Australia’s BERD as a percentage of GDP remains below the OECD average of 1.58% in 2010; however, the difference is only 0.20 percentage points. The significant increase in BERD/GDP ratio that Australia has experienced in more than a decade meant that this ratio more than doubled from 0.62% in 1999–2000 to the current 1.28%. In other words, over this period Australia has increased its BERD-to-GDP ratio from 42% to 81% of the OECD average. This is a significant transformation towards a knowledge-based economy.

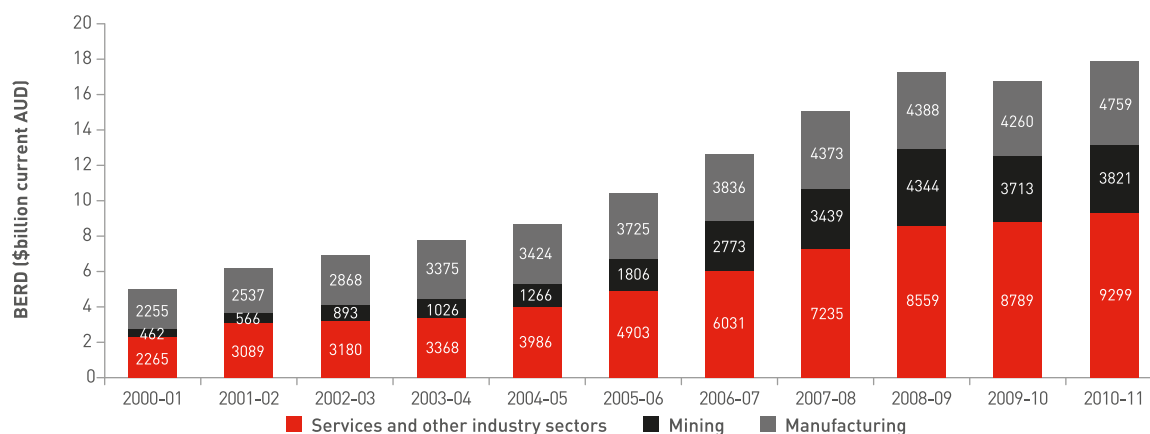
Australian businesses spent a record \$17,880 million on R&D in 2010–11, compared with \$16,762 million in 2009–10, an increase of 6.7% in current prices (Chart 2.8). In real terms business expenditure on R&D (BERD) grew by 6.2% over the same period. Over the five years to 2010–11, BERD increased at an average annual rate of 9.1% in current prices and 6.0% in real terms. The proportion of businesses innovating has grown marginally over the same five year period.

Chart 2.8 shows that manufacturing still contributed the greatest share of any single industry toward BERD—at \$4.76 billion or 27% of total BERD in 2010–11. Mining followed with \$3.82 billion (21%). Financial and insurance services R&D expenditure was \$2.75 billion (15%) and professional, scientific and technical services \$2.70 billion (15%). These two service sectors contributed more than 59% of the total services sector expenditure on R&D (\$9.3 billion) in 2010–11. Large firms dominate investment in R&D in almost every sector.¹³⁵ The rates of growth in BERD are much higher than growth rates of the proportion of innovation-active businesses suggesting that the majority of BERD growth is coming from increased investment by existing large R&D performers rather than the introduction of new R&D performing businesses. The relationship between R&D and innovation is intuitive but not as strong in Australia as it is in other countries.¹³⁶ Total expenditure on innovation by Australian business was estimated to be between \$23 billion and \$29 billion in 2010–11. With close to \$18 billion of BERD in the same year, further analysis is required to explore the relationship between R&D inputs and innovation outputs across all business sizes and sectors.

¹³⁵ Australian Government (2011) *Australian Innovation System Report – 2011*, DIISR, Canberra, p.60.

¹³⁶ OECD (2010) *Measuring Innovation: A new perspective*, OECD Publishing, p.23.

Chart 2.8 Comparison of manufacturing; mining; and services and other industry sectors BERD: 2000–01 to 2010–11



Source: (ABS) *Research and Experimental Development, Businesses, Australia*, cat. no. 8104.0

Framework conditions for innovation

Table 2.4 shows Australia's performance against a range of innovation framework conditions. Generally, most measures deteriorated since the onset of the global financial crisis, with some, including early stage venture capital investment, showing signs of recovery. Lack of access to additional funds as a barrier to innovation has increased to 21% of innovators since 2006–07.

Total investment in venture capital reached its lowest levels of \$259 million during 2010–11 since data has been collected in this format (2005–06). Investment has since increased to \$331 million in 2011–12, but is still well below the pre-GFC peak of \$901 million in 2007–08. This trend suggests that it may take a number of years for the industry to rebuild to pre-GFC levels. Investment in the earlier, higher risk stages is consistently lower than investment at the latter, comparatively lower risk stages. Regarding the average proportions across all years (2005–06–2011–12), pre-seed and seed¹³⁷ accounted for 6% of total investment; start-up 24%; and early expansion 70%.

Comparative indicators of the financial environment show that there is a perception in the business community that Australia still provides a reasonable environment to undertake business compared with most other OECD countries. For example, in response to the question about how easy it is to raise money by issuing shares on the stock market, Australia ranked 6th, which is considerably better than the OECD average (Table 2.4). Indicators related to ease of access to loans and venture capital show perceptions of the Australian market are still more favourable than the OECD average, but less positive than in previous years. This shows that even when the Australian financial environment is quite stable, venture capital markets are still cautious. Indicators associated with the financial dynamism of the Australian economy, such as market capitalization and stocks traded, show that the recovery to pre-GFC levels has not been automatic and is taking some time. However, in these types of indicators, Australia is in a significantly better position than the OECD average (Table 2.4).

The production and use of technology is a proxy for the demand for and drivers of innovation. A number of technology-related indicators are presented in Table 2.4. The production of technologically intensive goods has declined over the last five years—from 2.6% in 2006 to 2.2% of GDP. Matching this decline has been a reduction in government procurement of advanced technological products, according to the WEF perception based survey. The same survey has shown, however, that businesses absorb technology more readily than five years ago (the firm level technology absorption indicator). Other non-perception-based indicators show that Australians demand more goods and services related to health, communication and education, with final consumption of these goods having risen from 9.6% in 1995 to 12.6% in 2011.

137 Due to confidentiality requirements of the ABS, it is not possible to separate the pre-seed and seed stages for every year.

Economic conditions

Broader economic framework conditions feed the opportunities and incentives that are needed to drive innovation. Table 2.5 sets out a range of economic indicators since 1995. Australia has now experienced 21 years of consecutive growth in the period to 2012. Up until recently, Australia has been ranked among the top five most resilient countries to economic cycles (see Table i.1).¹³⁸ This trend is at odds with most other developed economies. It is the longest period in Australia's recent economic history without a technical recession.¹³⁹ In some respects, when compared with the 1970s and 1980s, Australia has avoided extremes of inflation, while enjoying low or declining unemployment, rising workforce participation and per capita income. In fact, unemployment has been maintained at the near-full employment level of between 4% and 6% for the past decade and, even at the height of the global financial crisis (GFC) in mid-2009, peaked at just under 6%.

Australia has experienced strong GDP growth from the mid-1990s, with the exception of 2009–2011 when the rate of economic growth declined, but remained positive, during the GFC (Table 2.5). The impact of the GFC on the Australian economy can also be observed in the large drop in business confidence from 5.12 in 2007 to 20.70 in 2008 and recovery to 8.60 in 2009. Factors that explain why Australia emerged relatively unscathed through the GFC and more recent contractions overseas include:

- The strength of the fiscal and monetary response in 2008–09.
- The health of the banking sector and its prudential controls.
- Resurgent demand from China for Australian commodities.
- The apparent absence of a housing bubble.
- Low public debt.
- Relatively high population growth.
- The flexibility of exchange rates and the labour market.¹⁴⁰

138 IMD, World Competitiveness Online 1995–2012.

139 A technical recession is defined as two consecutive quarters of negative growth.

140 IMF (2010) *Australia-010 Article IV Consultation Concluding Statement*, International Monetary Fund, Washington DC.

Table 2.4 Indicators of finance and entrepreneurship in Australia

Indicators	Australian trend data ⁽ⁱ⁾											OECD comparison			
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	Australia's score ⁽ⁱⁱ⁾	OECD average ⁽ⁱⁱⁱ⁾	OECD top 5 average ^(iv)	Gap from the top 5 OECD performers ^(v)	Ranking against OECD countries ^(vi)
Early stage venture capital investment (\$m) ^{1,(a)}	-	-	178	136	249	208	147	110	150	-	-	-	-	-	-
Venture Capital investment (\$m) ^{1,(b)}	-	-	605	813	901	683	420	259	331	-	-	-	-	-	-
Later Stage Private Equity investment (\$m) ^{1,(c)}	-	-	1177	1992	1868	994	824	955	596	-	-	-	-	-	-
Venture capital investment as a % of GDP ^{1-3,(b)}	-	-	0.061	0.075	0.077	0.054	0.032	0.018	0.022	-	0.021	0.044	0.146	86	18th
Proportion of businesses seeking debt or equity finance for innovation [% of respondents] ⁴	-	-	12.7	13.6	15.4	12.7	11.1	8.2	-	-	-	-	-	-	-
Financing through local equity markets ^{5,(d)}	-	-	-	6.31	5.89	5.34	4.06	4.59	4.66	4.72	4.72	3.93	4.88	3	6th
Ease of access to loans ^{5,(e)}	-	-	-	4.83	4.88	4.94	4.4	3.92	3.68	3.68	3.68	3.12	4.34	15	11th
Venture capital availability ^{5,(f)}	-	-	-	4.83	4.66	4.43	3.97	3.83	3.54	3.34	3.34	3.06	4.24	21	13th
Market capitalization of listed companies (% of GDP) ⁶	-	-	116.1	147.1	152.7	64.2	136.3	127.8	86.6	84.6	84.6	62.5	130.7	35	9th
Stocks traded, total value (current US \$billion) ⁶	-	-	616	826	1323	1018	762	1222	1246	1052	1052	1122	6042	83	9th
Stocks traded, total value [% of GDP] ⁶	-	-	89.0	110.9	155.5	96.7	82.5	107.3	90.0	69.2	69.2	39.7	110.7	38	7th
Stocks traded, turnover ratio [%] ⁶	-	-	78.0	87.0	110.5	103.1	78.8	90.1	94.0	84.7	84.7	59.8	134.7	37	8th
Barriers to innovation - Any barrier [% of respondents] ⁴	-	-	-	46.3	43.7	43.2	44.8	44.9	-	-	-	-	-	-	-
Lack of access to additional funds [% of respondents] ⁴	-	-	-	15.9	16	19.5	18.4	21.1	-	-	-	-	-	-	-
Government regulations or compliance [% of respondents] ⁴	-	-	-	10.3	10.6	11.9	14.5	13	-	-	-	-	-	-	-
Government procurement of advanced technology products ^{5,(g)}	-	-	-	4.0	4.2	4.1	4.0	4.1	3.9	3.7	3.7	3.8	4.52	19	23rd
Firm level technology absorption ^{5,(h)}	-	-	-	5.5	5.7	5.8	5.9	5.9	5.8	5.9	5.9	5.5	6.22	5	11th
Entrepreneurial intentions ⁷	-	-	-	12	10.6	-	-	8.7	12.3	-	12.3	12.9	26.04	53	9th
Buyer sophistication ^{5,(i)}	-	-	-	5.8	5.3	4.80	4.7	4.4	4.2	4.1	4.12	4.1	5.04	18	20th
Percentage of final household consumption expenditure on Health, Communications and Education ⁸	9.6	10.5	11.9	12	11.9	12.2	12.4	12.4	12.6	-	12.6	9.1	15.8	20	3rd

Indicators	Australian trend data ⁽ⁱ⁾										OECD comparison				
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	Australia's score ⁽ⁱⁱ⁾	OECD average ⁽ⁱⁱⁱ⁾	OECD top 5 average ^(iv)	Gap from the top 5 OECD performers ^(v) [%] ^(vi)	Ranking against OECD countries ^(vi)
Barriers to entrepreneurship ⁹	-	-	-	-	-	1.1	-	-	-	-	1.1	1.4	1.0	18	7
Statutory corporate income tax rates (%) ¹⁰	-	-	-	30	30	30	30	30	30	30	30	25.2	17.2	74	16th
Start-up procedures to register a business (number) ⁶	-	-	2	2	2	2	2	2	2	2	2	5	-	-	-
Cost of business start-up procedures (% of GNI per capita) ⁶	-	-	1.9	1.8	0.8	0.8	0.8	0.8	0.7	0.7	0.7	4.9	0.26	169	6th

Sources: [1] ABS (various) *Venture Capital and Later Stage Private Equity, Australia*, cat. no. 5678.0 and DIICSRTE calculations. [2] ABS (2012) *Australian National Accounts: National Income, Expenditure and Product, Mar. 2013*, cat. no. 5206.0. [3] OECD, *Entrepreneurship at a Glance 2013* for the OECD comparison data. [4] ABS (various) *Selected Characteristics of Australian Business*, excluding agriculture, Cat. no. 8167.0. [5] World Economic Forum, *The Global Competitiveness Report (various editions)*. [6] World Bank (2013) *World Development Indicators & Global Development Finance* [7] *Global Entrepreneurship Monitor (GEM); Adult Population Survey, 2010 & 2011*. [8] OECD Stat. database. [9] OECD (2010) *Measuring Innovation: A New Perspective*, Paris. [10] KPMG (2012) *Corporate tax rates by country table*, KPMG Global Website. www.kpmg.com

Indicator notes: (a) Early stage venture capital investment = Pre-seed + Seed + Start-up. (b) Venture capital investment = Early stage venture capital investment + early expansion stage. (c) Later Stage Private Equity investment = Turnaround; LBO/MB0/MBI stages. (d) For this indicator, survey respondents were asked to answer the question: How easy is it to raise money by issuing shares on the stock market in your country? [1 = very difficult; 7 = very easy]. (e) For this indicator, survey respondents were asked to answer the question: How easy is it to obtain a bank loan in your country with only a good business plan and no collateral? [1 = very difficult; 7 = very easy]. (f) For this indicator, survey respondents were asked to answer the question: how easy is it for entrepreneurs with innovative but risky projects to find venture capital? [1 = very difficult; 7 = very easy]. (g) For this indicator, survey respondents were asked to answer the question: Do government procurement decisions foster technological innovation in your country? [1 = no, not at all; 7 = yes, extremely effectively]. (h) For this indicator, survey respondents were asked to answer the question: To what extent do businesses in your country absorb new technology? [1 = not at all; 7 = aggressively absorb]. (i) For this indicator, survey respondents were asked to answer the question: In your country, how do buyers make purchasing decisions? [1 = based solely on the lowest price; 7 = based on a sophisticated analysis of performance attributes].

Table notes: (i) Data is presented in calendar year format. Where the data is in financial years, it is expressed in terms of the year where the financial year begins e.g. 2010-11 is shown as 2010. (ii) The 'Australia's score' field presents the Australian values used in the OECD comparisons. (iii) This is the arithmetic (simple) average of the OECD country scores. (iv) This is the arithmetic (simple) average of the top five OECD countries in a ranked list. (v) This represents Australia's distance from the frontier as defined by the average of the top five ranked OECD countries. It is calculated as 100* [(Top five average - Australia's score)/Top 5 average]. Where the solution is a negative value or zero, "no gap" is shown in the cell. (vi) OECD rankings are performed on those OECD countries for which data is available. Individual data availability may vary between indicators. "-" = data not available.

Table 2.5 Australia's key macroeconomic indicators

Indicators	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
Real Gross Domestic Product (GDP), \$billion ^{1, (a)}	824	1014	1190	1226	1273	1321	1343	1371	1404	1451
Real GDP Growth from previous year (%) ^{2, (a)}	4.0	3.8	3.2	3.0	3.8	3.8	1.6	2.1	2.4	3.4
Operating surplus as % GDP ^{3, (b)}	22.6	22.4	23.8	25.4	24.4	24.3	27.1	25.5	25.7	25.5
Index of Industrial Production ^{4, (c)}	72.2	82.1	89.4	90.2	94.4	96.8	96.5	100.6	100.0	102.2
Index of capacity utilisation (%) ^{5, (d)}	79.5	79.4	82.6	82.6	82.8	80.6	81.4	82.1	80.8	79.7
Industry Value Added (chain volume measures), \$billion ^{6, (d)}	761	938	1,103	1,138	1,182	1,228	1,251	1,279	1,310	1,353
Unemployment rate (%) ^{7, (e)}	8.3	6.2	5.0	4.8	4.3	4.3	5.9	5.2	5.0	5.2
Inflation Rate (CPI) ^{8, (e)}	4.9	5.8	2.7	3.3	3.0	3.6	2.2	2.6	3.1	2.2
ASX all ordinaries share price index ^{9, (f)}	2,203	3,206	4,763	5,670	6,340	3,722	4,871	4,745	4,057	4,649
Trade Weighted Index (TWI) ¹⁰	53.9	51.6	62.7	64.9	68.7	55.6	69.7	75.8	75.8	77.1
Business Confidence Survey ^{11, (e), (g)}	7.7	-2.9	7.1	5.7	5.1	-20.7	8.6	-2.8	2.3	2.5

Sources: [1] ABS (2013) *Australian System of National Accounts, 2011-12*, Table 2. Expenditure on Gross Domestic Product (GDP), cat. no. 5204.0. [2] ABS (2013) *Australian System of National Accounts, 2011-12*, Table 1. Key National Accounts Aggregates, cat. no. 5204.0. [3] ABS (2013), *Australian System of National Accounts, 2011-12*, Table 17. Non-Financial Corporations Income Account, and Table 1, Key National Accounts Aggregates cat. no. 5204.0. [4] ABS (2013) *Australian National Accounts: National Income, Expenditure and Product, Mar 2013*, Table 39, Indexes of Industrial Production, cat. no. 5206.0. [5] Thomson Reuters DataStream (2013) Industry Production and Utilisation. [6] ABS (2013) *Australian National Accounts: National Income, Expenditure and Product, Mar 2013*, Table 33, Industry Gross Value Added, cat. no. 5206.0. [7] ABS (2013) *Labour Force, Australia, May 2013*, Table 2, Labour force status by Sex, cat. no. 6202.0. [8] RBA (2013) Statistical Tables, G1, Measures of Consumer Price Inflation. [9] Thomson Reuters DataStream (2013) Stocks and Bonds. [10] RBA (2013) Trade Weighted Index (TWI). [11] Thomson Reuters DataStream (2013), National Australia Bank (NAB) Business Survey.

Indicator notes: (a) Chain volume measures in original term and annual time series from June to June. (b) Gross operating surplus (GOS), current prices in original term; GDP, current price in original term. Index is calculated as (GOS/GDP x 100%). (c) Index numbers in original term, and annual time series available from June 1975 to June 2012. (d) Monthly and seasonally adjusted time series available from Mar 1997 to May 2013. The data of 1997 is used for 1995. (e) Monthly and seasonally adjusted time series. (f) Monthly time series and not seasonally. (g) The data of 1997 is used for 1995.

Another reflection of a strong Australian economy is consistently low unemployment, which has dropped below 5% in the period between 2005 and the GFC in 2009 (Table 2.5). Of course, low unemployment and commensurate increases in sectoral and geographic labour demand have driven the need for increased skilled migration (Chapter 1) and greater innovation. Despite much of Europe again falling into recession by the December quarter of 2012, Australia continued to record positive GDP growth of 3.1% [seasonally adjusted] year-on-year to December 2012. Seasonally adjusted unemployment has risen slightly to 5.5% in May 2013, while moderate employment growth of 1.3% was experienced in calendar year 2012. Forward indicators for employment, however, suggest that unemployment may rise further. The current account deficit was a respectable 3.9% of GDP in the December quarter of 2012. Despite concerns about declining multifactor productivity growth in some industries, when measured in terms of gross value added per hour worked in the market sector, labour productivity rose 3.3% through the year to December 2012.¹⁴¹

The surge in export growth as a result of demand for Australian commodities from China has meant that Australia's trade-weighted index has increased in the last decade. The Australian dollar reached parity with the US dollar in 2010 before falling below parity again in May 2013. The ASX All Ordinaries share price index peaked in 2007, but fell sharply during the GFC, before rising steadily. But it has failed to again reach its 2007 peak.

These framework conditions ought therefore to bode well for Australian innovation. However, innovation has only marginally increased in the last six years despite increasing investment. Buoyant economic conditions ought to stimulate investment by enterprises in research and development as vital input to innovation. Australia faces a number of impediments in adapting to current challenges, including lack of scale in the domestic market, low connectedness to global innovation, relatively low levels of collaboration, limited access to global supply chains, lagging infrastructure and only moderate levels of business sophistication. However, as discussed in Chapter 1, Australia's increasing connectedness to rapidly growing Asian economies may well be increasingly important in offsetting some of these challenges through increased trade in goods and services, international research and business collaborations.

In addition, the moderation and relative resilience mask some important and challenging trends in Australia's economic development and industrial structures that are also vital for the national innovation system. These trends are often responsive to and, in some cases, have insulated Australia from the volatility of external markets. To a greater extent than ever before, rapid economic growth in Asia is becoming imperative to economic conditions in Australia and, hence, to its changing industrial and innovation structures.

FEATURE: AUSTRALIA'S ECONOMY IS CHANGING SHAPE

By Chris Richardson, Deloitte Access Economics

Australia's economy is changing shape, responding to the lift in growth across the emerging world evident over the past decade, as well as to a wave of new technologies.

While much of this report considers the latter, a focus on the former may also be handy here. In brief, there is an industrial revolution underway in half the world – people are shifting from farm to factory work. That's already been a game changer for China, and the likes of India and other nations are following suit. And when half the world has an industrial revolution, that boosts the demand for, and price of, commodities such as thermal coal and iron ore.

In turn, that is why Australia was the fastest growing rich Western nation in the world in the past decade, and it's why the consensus is that we'll retain the title in the coming decade. We have what the world wants: unlike many other rich economies, we are rich in resources.

These emerging economy gains led not just to higher commodity prices, but also to a surge in construction, with mega mining projects now dotting the Australian industrial landscape.

Indeed, although the global financial crisis grabbed the headlines, the biggest development for Australia's economy over the past decade has been our ability to sell into the rise of emerging economies. It explains why most of the growth in Australia in recent years hasn't been driven by the spending of families or governments or by the building of new homes.

Rather, our growth has been driven by businesses putting their money where their mouth is and investing in new capacity. Businesses, especially in the resources sector, are doing that because they think there's a buck in it – that the new capacity will generate more profits.

Yet the good news of the past decade came with challenges too. Notably, as commodity prices rose, so did the Australian dollar. And although our ability to sell into emerging Asia helped our economy, it also kept interest rates higher here than in the rest of the rich world.

The upshot was a deadly duo – the relative strength in Australian exchange and interest rates – which has weighed heavily on many businesses. Further, and atop those existing challenges from exchange and interest rates, the second half of 2012 saw the pace of growth in emerging economies step back, with commodity prices doing the same.

That helped draw attention to the fact that the resources boom and its impact in Australia is already in transition. No, the mining boom isn't over. But it is changing.

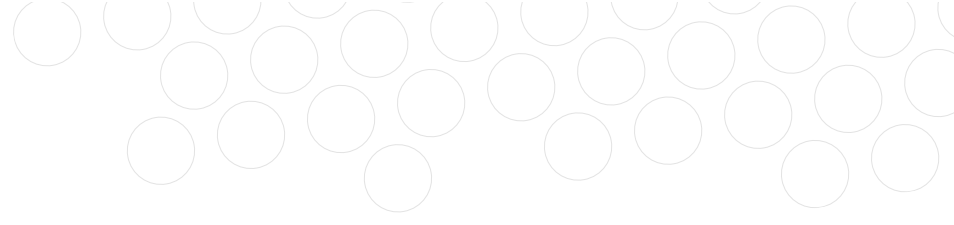
Think of it this way – the mining boom has three linked effects; via (1) commodity prices, via (2) the strength of resource-related construction, and via (3) resource-related export volumes.

Looking at those effects, (1) is unlikely the world will ever see anything like the commodity price peaks of 2011 ever again – or at least not for some time. And (2) there's now a realisation that the peak in Australia's resource-related construction is closer than many had realised. On the upside, (3) the export dividend is growing fast, and will ultimately be huge.

It's the fading of the second effect – a change in resource-related construction – that is now capturing attention. Partly in response to the related risk of a coming 'pothole' in Australian growth, the Reserve Bank has already cut interest rates. And although its early days yet, that will show up via a growth dividend in retail (the biggest part of Australia's economy) and housing construction (the most volatile part of Australia's economy). These and other 'interest rate sensitive sectors' are likely to see better news through the course of 2013.

Yet there's a question mark over 'dollar dependent sectors' – a group including manufacturers, farmers, tourism and those providing education services to foreign students. This group has had to grapple with an Australian dollar close to parity with its US cousin over the past two years.





The \$A may not remain as strong in coming years. Even so, however, much of the pothole in growth created by slowing spending on mining construction projects may have to be filled by the 'interest rate sensitive sectors' rather than 'dollar dependent sectors'.

It's also important to note that the Federal Government has slowed its search for a Budget surplus. That has taken some pressure off not merely the public sector itself, but some other related sectors as well.

And so that's the growth calculus for Australian industries in the coming year. The structural changes which saw a swing towards the construction of huge mining projects will soon slow. That doesn't mean mining production itself takes a hit. To the contrary – it will grow fast not merely this year, but the coming five years. Yet the strength in resource construction will soon ease back, while some other sectors that have been on the back foot as they've battled the strength of the Australian dollar are likely to continue to be under pressure. Although they won't shrink in size, manufacturing, tourism, farming and international education are unlikely to be big growth drivers in the short term. At the same time, some government cutbacks mean the public sector will also be among the slow growing group of Australian industries.

Yet there will be good news for some sectors which have been struggling. Although digital disruption (including the rise of online sales) will pose continuing challenges for retailers, macro conditions are swinging their way. Interest rates are down and, thanks to gains in share prices and housing prices, wealth is up. That may spell better news for retailers than has been evident for some time.

Similarly, the demand will improve for housing construction. The latter has been a broadly shrinking share of Australia's economy over the past decade. However, lower interest rates and an increased emphasis from state governments and local councils on land release looks set to generate some good news on that front.

The bottom line? That suggest the gaps in Australia's patchwork economy may start to close over the coming year, with some areas that have been strong (such as resource-related construction) coming off the boil, while others that have been struggling (such as retail and housing construction) may start to gain more traction.

CASE STUDY: Aqua Armour™ EVAPORATION AND ALGAL CONTROL SYSTEM FOR URBAN WATER, MINING AND AGRICULTURE WATER STORAGE

Aqua Armour™ is an evaporation and algal control system that prevents 88% of evaporative losses and inhibits algal growth. The Aqua Armour™ system is Australian designed, engineered and manufactured and was launched in 2010 after 5 years of development. The system is scalable to any size water storage, dam and reservoir.



Caption: Aqua Armour™ modules deployed at Ouyen, Victoria.

Image provided by Jennie Fallett.

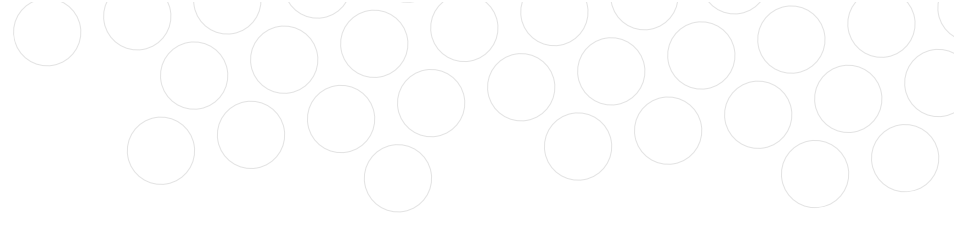
Water resources are a critical asset to all, supporting the environment, cities and towns, the economy and social amenities. Water of adequate quantity and quality is the corner stone that is central to the integrity of the environment/environmental flows and the ongoing maintenance of Australia's ecosystem.

With the rapid increase in population growth along with economic expansion, demand and reliance on our water resources will certainly increase. In the hundreds of towns and communities around Australia, water storages, dams, reservoirs and water treatment plants are in operation providing both water security and water quality to all.

The two major threats to the security and quality of our water are evaporative losses and algal contamination.

1. Reducing Evaporative Losses by 88%: In Australia alone, evaporation loss represents approximately four times the total annual rainfall of the country and may result in a loss of between 1.6 – 4 metres of water each year from the surface of open storages. Evaporation occurs 24/7 but is invisible and this wastage significantly reduces the amount of stored and high security water actually available for industrial uses. Within the majority of towns and communities around Australia water restrictions are in place or have been in place for many years due to uncertain environmental conditions in which evaporation plays a significant contributing role.





Aqua Armour™ is extremely cost competitive, environmentally friendly and does not have the need of infrastructure requirements. Once deployed, Aqua Armour™ does not require any ongoing energy cost for the mega litres of water it provides by preventing 88% of evaporative losses, unlike alternative methods such as desalination or recycling waste water.

2. Prevention of Algal Contamination: Water storages require aeration (pumping costs) and chemical treatment to reduce the risk of toxic algal blooms. However in some cases the water becomes untreatable, leading to the contaminated water having to be disposed of.

Aqua Armour™ inhibits algal growth by preventing 95% of photosynthetically active radiation light (PAR Light) onto the water surface beneath the Aqua Armour™ modules. The prevention of PAR light provides a cooler and darker environment directly underneath the Aqua Armour™ modules, leading to a proven reduction in algal counts by 91 to 93% without any negative impact on dissolved oxygen or micro invertebrate life.



Caption: On-site Aqua Armour™ assembly system

Image provided by Tim Grogan

Additional benefits include:

- Reduced reliance on water supply to replace evaporative losses
- Significant reduction of wave body action, preventing bank erosion
- Savings to pumping and energy costs
- Reduction in chemical usage for the treatment of algal contamination
- Water storage and dam construction cost savings (a smaller storage or dam is required if Aqua Armour™ is to be deployed)
- 20 year infrastructure solution with very little maintenance required.

Aqua Armour™ has been deployed onto:

- Raw water Storages
- Community Wastewater Management Schemes – CWMS
- Settling storages and lagoons





- Chlorine contact tank/Storage
- Effluent storage ponds
- Stormwater harvest and recovery storages
- Reverse osmosis water storages

The AquaGuardian Group is wholly focused at present around the commercial roll-out of AquaArmour and plans to grow its employee numbers (including field staff) to meet the demand for the product, with deployment teams based in relevant states & territories in Australia and overseas. In addition, AquaGuardian Group is currently evaluating some potential partnerships in some overseas territories to accelerate market penetration in those areas. They have also identified further product enhancements for AquaArmour and also several related product opportunities that are tailored to certain deployment conditions. AquaGuardian Group plans to invest further in the development of these as their capital base allows.

For more information visit www.aquaarmour.com.au

CASE STUDY: F CUBED AUSTRALIA PTY LTD- SOLAR WATER PROCESSORS

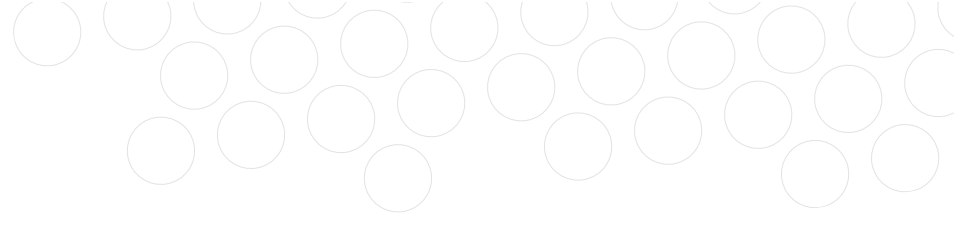
F Cubed is dedicated to being the global leader in producing and delivering cutting edge direct solar water processing technologies, cost effective strategies and sustainable innovation for the world's most precious resource, water. There are over 1 billion people in the world without access to clean drinking water causing a daily death rate of 10,000 people due to water borne diseases, the majority being children. Following the bio mimicry of the natural water cycle F Cubed Australia has developed a world first in solar desalination.

F Cubed (which means film, frame + fabrication) is using solar energy as a water treatment method. Established in 2005, we spent 5 years researching and developing processes to finalize our unique CAROCELL® panel design in late 2009. The Australian manufacturing facility started production mid-2010, which included the design and manufacturing of specific machinery for commercial production volumes. The panel has undergone global field testing, in relation to transportability, installation, operation and reliability. Our experiences have resulted in the current series-3 design, which improved performance and simplified the operation of the panel.



Caption: Carocell units processing waste wash down water from tractors and spraying equipment at a vegetable farm in Victoria. Image provided by F Cubed Australia.





Caption: Pilot testing of pit water for a Gold mine in WA. Starting Total Dissolved Solids was 160,000 ppm (over four times that of seawater) and once treated by the Carocell unit was 0-3 ppm.

Images provided by Stuart Eastaugh

F Cubed strategic plan is to have strategic partners, agreements, offices and representation in countries that have water issues. F Cubed strategic plan also incorporates up-scaling of current production facilities with new factories in 4-5 regions strategically positioned close to major markets.

To this point the F Cubed offices have been established within the targeted countries. F Cubed Head Office is located in Melbourne, Australia, with subsidiaries/ representative offices in: Monaco, Monte Carlo, Cambodia, Philippines, Bangladesh, Indonesia and Vietnam. This has provided the framework for the initial export containers with 70% into the South East Asian countries (Philippines, Bangladesh, Indonesia, Malaysia, Vietnam and Cambodia). The ability of the Carocell system to operate as a high tech low tech solution provides these developing countries with decentralized Point of Use water system without heavy investment in infrastructure which is normally required for centralized water treatment plant. Having product in the field in the targeted countries provides positive reassurance of the Carocell system's and F Cubed's ability of the product and that of the companies capability to supply. F Cubed has invested heavily in face to face meetings and onsite demonstrations in these target countries this also provides F Cubed with the opportunity to evaluated potential strategic partners.

Commercial sales have taken place in 23 countries (Australia, Bangladesh, Botswana, Brazil, Cambodia, Dominican Republic, India, Indonesia, Kenya, Malaysia, Myanmar, Nauru, New Zealand, Vietnam, Panama, Peru, Philippines, Qatar, Samoa, Saudi, Tanzania, Uganda, USA) with pilot and testing continuing in an additional 13 countries (Abu Dhabi, China, Egypt, Fiji, Italy, Jamaica, Monaco, Mexico, Nigeria, Pakistan, Sri Lanka, South Africa, Thailand).





Caption: Resolving the daily canoe trip to another island to collect fresh water, the Lions Club of Apia contributed 40 Carocell units to the community of Manono Island in Samoa to process seawater into drinking water. Images provided by F Cubed Australia.

Images provided by Stuart Eastaugh

The demand for a sustainable potable solution is continuing to grow with increasing population and contamination of water sources through pollution and climate change. The Carocell solar desalination system being a modular design is able to be operated in developing countries as either a POU (point of use) single panel for a home, operating direct on solar energy with no ongoing operational costs and minimal maintenance, or in multi panel installations creating centralized water farms for entire communities or commercial applications.

The production rates and the efficiency of CAROCELL® panels can be enhanced, by pre-heated water delivered to the panels from a waste heat source; such as cooling water from a power station which creates a Hybrid system operating 24 hours a day.

The Carocell system is able to continually reprocess its own waste stream with each cycle extracting pure water and reducing the volume of brine, with seawater the extraction rate is 90% with the final 10% being sent to ZLD (zero liquid discharge) trays for fractionalization of the salts. This uniqueness of the Carocell system provides the opportunity for the treatment of waste water (commercial/mining/RO Brine/Leachate/Coal seam Gas water etc.) which previously was sent to evaporation ponds to now be repossessed extracting pure water and reducing the potential contamination of the environment.

Three hundred million households a day worldwide boil water as their main water purification method. The predominant fuel for this is wood. If each household is boiling 10 litres of water a day, they also produce approximately 10kg of CO₂/day. This means approximately 4 tonnes of CO₂ per year. By replacing boiling through CAROCELL® panel a carbon credit of 1.2 billion tonnes per year is available under a CDM POA besides saving all that wood for our environment.

For more information visit www.fcubed.com.au

CASE STUDY: HOLOCENTRIC INNOVATING BUSINESS MANAGEMENT SYSTEMS



Holocentric was formed in 2003 from academic research at Sydney University and with government support the company evolved to offer a world leading business management system (BMS) solution in the Australian and expanding Asian markets.

The key to this innovation was Holocentric identifying that most large organisations, including government agencies, struggle to understand the complexity of their own processes, thus exposing themselves to compliance and governance risks and organisational inefficiencies. As the wider business and government community expands to engage with new environments, complexity will increase significantly and require greater management and governance in turn adding significant cost. The ability to effectively navigate the inevitable complexity from both a government and business perspective is an important competitive facility.

The Holocentric Business Management System (BMS) platform enables organisations to achieve operational excellence and manage business transformations. This is achieved by understanding, capturing and modelling the details of the organisation's strategy, legislative obligations, process, requirements and other important corporate knowledge. Information is then displayed alongside Key Performance Indicators, costs and other metrics in the context of the business, process or organisational unit as appropriate. The BMS also incorporates legislative and regulatory requirements on activities undertaken by the organisation when required.

Many large and mature Australian companies have now recognised the value of this approach and are increasingly employing the Holocentric platform to power and de-risk business transformations, and large projects. Customers attest to improved requirements management, better end-to-end business visibility, and a better solution for modelling, documenting, managing and in some cases automating complex business processes.

As Australia evolves stronger political, social and trading ties with Asia the example being set by Holocentric customers provides a well-documented, modelled and replicable lead in BMS excellence. Australian companies are now selling the business frameworks developed with Holocentric to their Asian partners to ensure best practice, compliance and efficiencies.

Holocentric's success in the Australian aviation sector is now generating opportunities with highly competitive Asian airlines looking for any organisational process improvements to maintain thin profit margins. From Hong Kong to Singapore Holocentric are providing better business management solutions and a competitive edge.

With the Asian Century driving the future global economy, Holocentric are focusing on their efforts on Asia expansion and regional partnering opportunities to compete in this market.

For more information visit www.holocentric.com

CHAPTER 3: SKILLS FOR INNOVATION AND ENGAGEMENT WITH ASIA

The relationship between innovation and skills

It has been widely acknowledged that innovation is about creative, skilled and motivated people.¹⁴² A highly skilled, creative and motivated workforce will drive up participation rates, address skill shortages and boost productivity. Australia's advanced education and training system and its highly skilled workforce are existing comparative advantages that can be built upon to compete for the rapidly growing Asian markets.¹⁴³ The challenge is to maintain the excellence of the education and training system and build its flexibility to adapt to challenges and opportunities coming from closer integration of Australian and Asian innovation systems.

As innovation occurs in all sectors throughout the economy and in all stages of production and distribution, the skills needed are wide-ranging. These include technical skills such as those required for the trades, design and engineering, which are necessary for creating and diffusing new technologies and products, as well as management skills needed to adopt and adapt innovations.¹⁴⁴

More investment in human capital¹⁴⁵ can enhance Australia's national skills base and make more firms innovation-ready.¹⁴⁶ A country's skill base is most commonly measured by the proxy measure of education attainment. In Australia, the structure of education attainment of the workforce has changed significantly since the late 1990s, with the proportion of the working population (aged from 25 to 64 years) attaining a tertiary education qualification rising from 24% in 1997 to 38% in 2011 (Table 3.1).¹⁴⁷

There is much evidence that higher levels of education and training have a positive impact on the levels of innovation and employment.¹⁴⁸ Innovative businesses are generally more skills-focused and, compared with businesses that don't innovate, are more than twice as likely to increase employment.¹⁴⁹

In fact, the long-term relationship between skills, innovation and employment may be characterised as a 'virtuous cycle'.¹⁵⁰ The skills of the workforce underpin the rate and scale of innovation that takes place in the workplace; and the innovation, in turn, fuels the demand for more skilled workforce. An up-skilled workforce then becomes the source of further innovation; and thus the cycle goes on as the innovation frontier of the business, sector or system is pushed outwards.¹⁵¹

Previous Australian Innovation System reports show that in Australia the lack of skilled people has been the highest single reported barrier to innovation in businesses in recent years and that this barrier to innovation declines only as a result of the working population becoming more skilled.¹⁵²

142 Australian Government (2012) *Australian Innovation System Report—2012*, DIISRTE, Canberra, p.33.

143 Australian Government (2012) *Australia in the Asian Century White Paper*, PM & C, Canberra; also see Smith A, Courvisanos J, Tuck J & McEachern S (2012) *Building the capacity to innovate: the role of human capital*, NCVER, Adelaide.

144 UK Department for Business, Innovation and Skills (BIS) (2011) *Innovation and Research Strategy for Growth*, BIS Economics Paper No. 15, Department for Business, Innovation and Skills, London, p.111; also see Australian Government (2009) *Developing Innovation Skills: A guide for trainers and assessors to foster the innovation skills of learners through professional practice*, Innovation Business Skills Australia, East Melbourne pp.3–4.

145 Human capital refers to a set of attributes or competencies, such as knowledge, skills, creativity, work experience, health, and the capacity and motivation to muster these to produce social and economic value. The OECD defines human capital as productive wealth embodied in labour, skills and knowledge. Human capital may be acquired or enhanced through formal or informal education and training.

146 Australian Workforce and Productivity Agency (AWPA) (2013) *Human Capital and Productivity*, Literature Review, AWPA, Canberra, p.4.

147 AWPA (2013) *Future focus: National Workforce Development Strategy*, AWPA, Canberra, p.9.

148 Jones B & Grimshaw D (2012) *Training and skills to improve innovation in firms*, Manchester Institute of Innovation Research report for the National Endowment of Science, Technology and the Arts (NESTA), Manchester UK.

149 Australian Government (2012) *Australian Innovation System Report—2012*, DIISRTE, Canberra, p.5.

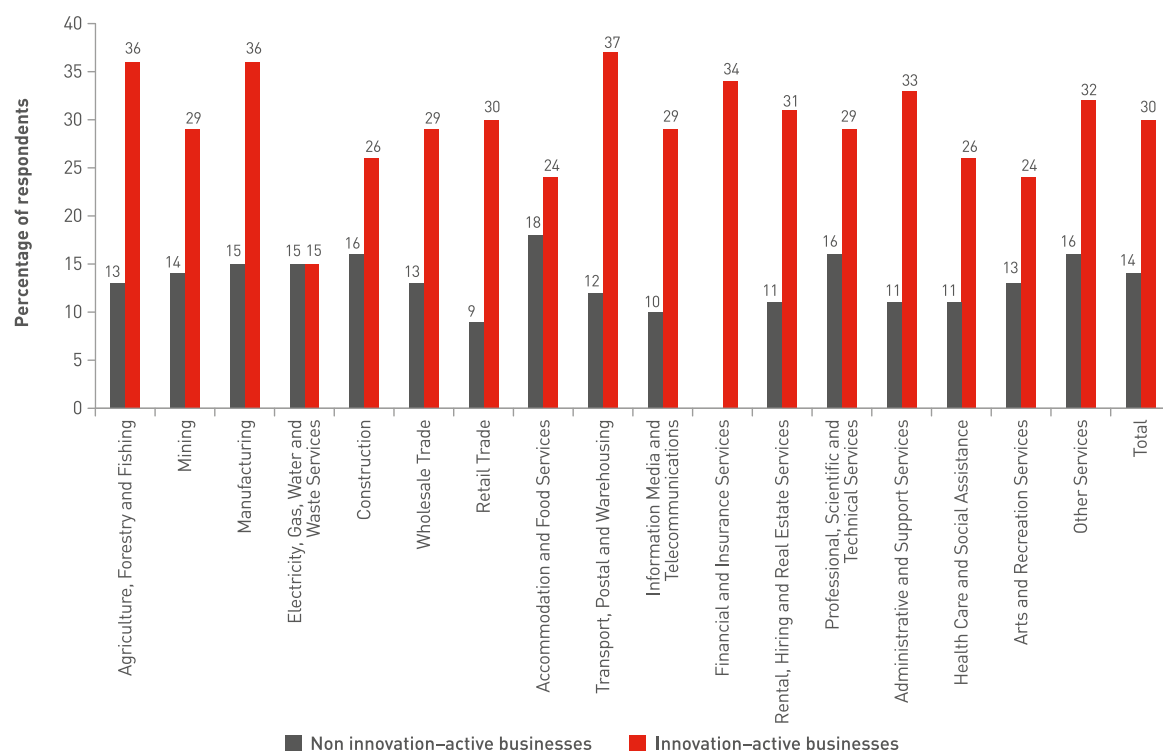
150 *Ibid*, p.30.

151 Tether B, Mina A, Consoli D & Gagliardi D (2005) *A literature review on skills and innovation; how does successful innovation impact on the demand for skills and how do skills drive innovation?* A CSIC (Centre for Research and Innovation Competition) report to the Department of Trade and Industry, Manchester, UK, pp.26–27.

152 Australian Government (2012) *Australian Innovation System Report—2012*, DIISRTE, Canberra, pp.10, 33; Australian Government (2011) *Australian Innovation System Report—2011*, DIISR, Canberra, p.36.

Data shows that innovative small and medium sized businesses (SMEs) are more likely to report lack of skills as a barrier to innovation than large firms.¹⁵³ Chart 3.1 illustrates the extent to which the lack of skills represents a barrier to innovation by industry sector. Consistently, across all industry sectors with the exception of Electricity, Gas and Waste Services, innovation-active firms are more likely (than non-innovation active firms) to indicate a lack of skills as a barrier to innovation. Innovation active firms in Transport, Postal and Warehousing; Manufacturing; and Agriculture, Forestry, and Fishing are the industry sectors that show the highest proportions at 36–37%.

Chart 3.1 Lack of skills as a barrier to innovation, by innovation status, by industry sector, 2010–11



Source: ABS (2012) *Selected Characteristics of Australian Businesses, 2010–2011*, cat. no. 8158.0.

Note: Data for non innovation-active businesses in the financial and insurance services sector was not available.

Data also indicates that the skills most used by innovation-active businesses in Australia in 2010–11 were business and project management skills, as well as marketing, financial and trades skills.¹⁵⁴ Innovative Australian businesses were, in fact, more than twice as likely to use business management and marketing skills compared to non-innovators.

Not surprisingly, innovative Australian businesses are also more likely than non-innovative businesses to report skills shortages. In skill categories most used, like management, marketing and finance, innovators have been two to three times more likely to report shortages. Even higher relative shortages (i.e. four to seven times higher) have been reported by innovators in scientific, research and information technology (IT) skill categories.¹⁵⁵

Data also shows that innovative businesses are more than three times more likely to increase training for employees than non-innovators.¹⁵⁶ In addition, the propensity of innovation-active firms in Australia to invest in training their employees is second only to their tendency to invest in acquisition of machinery, equipment or technology.¹⁵⁷

¹⁵³ ABS (2012) *Selected Characteristics of Australian Businesses, 2010–11*, cat. no. 8158.0.

¹⁵⁴ Australian Government (2012) *Australian Innovation System Report—2012*, DIISRTE, Canberra, p.36.

¹⁵⁵ *Ibid*, p.37.

¹⁵⁶ *Ibid*, p.39.

¹⁵⁷ *Ibid*, p.7.

Table 3.1 Australia's skills base

Indicators	Australian trend data ⁽ⁱ⁾										OECD comparison				
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	Australia's score ⁽ⁱⁱ⁾	OECD average ⁽ⁱⁱⁱ⁾	OECD top 5 average ^(iv)	Gap from the top 5 OECD performers ^(v) (%)	Ranking against OECD countries ^(vi)
Total expenditure on educational institutions as a percentage of GDP (%) ¹	5.05	5.22	5.31	5.71	5.18	5.18	6.00	6.13	-	-	6.13	6.26	7.68	20.2	18th
Expenditure on tertiary education institutions as a percentage of GDP (%) ¹	1.57	1.45	1.47	1.63	1.55	1.49	1.62	1.63	-	-	1.63	1.61	2.49	34.6	11th
Public expenditure on education as a percentage of GDP (%) ¹	4.80	4.58	4.52	4.60	4.28	5.18	4.99	5.15	-	-	5.15	6.26	7.87	34.5	22nd
Public expenditure on tertiary education as a percentage of GDP (%) ¹	-	1.16	1.14	1.13	1.00	0.97	1.10	1.15	-	-	1.15	1.38	2.24	48.7	19th
Expenditure on primary, secondary and post-secondary (non-tertiary educational) institutions as a percentage of GDP (%) ¹	3.39	3.64	3.74	3.99	3.51	3.57	4.22	4.35	-	-	4.35	3.92	4.93	11.9	8th
Percentage of 25-34 year olds with bachelor degree or higher (%) ¹	14.3	22.2	29.2	29.2	30.6	31.9	34.6	34.2	35.0	36.8	35.0	29.5	40.2	12.9	8th
Proportion of population aged 25-64 attaining tertiary education (%) ¹	-	19.2	31.7	33.0	33.7	35.6	36.9	37.6	38.3	-	38.3	31.5	45.4	15.5	9th
Proportion of population aged 25-34 with tertiary education (%) ¹	-	23.9	38.1	38.8	40.7	41.7	44.8	37.6	44.6	-	44.6	38.6	54.7	18.4	10th
Proportion of population aged 25-64 attaining upper secondary or post-secondary non-tertiary education (%) ¹	-	31.3	33.3	33.7	34.4	33.8	34.1	35.6	35.7	-	35.7	44.0	67.2	46.8	28th
Proportion of population aged 25-64 attaining below upper secondary school education (%) ¹	-	41.2	35.0	33.3	31.8	30.1	29.0	26.8	25.9	-	25.9	25.2	9.8	164	21st
Australia's share of international tertiary education market ¹	-	5.1	6.5	6.3	7.0	6.9	7.0	6.6	6.1	-	6.1	2.3	9.6	36.7	5th
PISA mean scores on reading ^{2,(a)}	-	528	525	513	-	-	515	-	-	-	515	496	528	2.5	6th
PISA mean scores on mathematics ^{2,(b)}	-	-	524	520	-	-	514	-	-	-	514	496	535	4	9th
PISA mean score on science ²	-	-	-	527	-	-	527	-	-	-	527	501	538	2.1	7th

Sources: [1] OECD (Various), Education at a Glance (various editions), [2] OECD (2010) PISA 2009 Results: Learning Trends: Changes in Student Performance Since 2000 (Volume VI).

Indicator notes: Comparisons of tertiary education indicators with the OECD need to be taken with caution as they may be affected by the different definitions of tertiary education in OECD countries that are not fully captured by the OECD classification. Comparisons with Australia of tertiary education using the OECD classification can be particularly problematic as the OECD definition of tertiary education is more restrictive than the Australian definition of tertiary education. The OECD definition of tertiary education only includes UNESCO's ISCED 5A, 5B and 6 levels while Australia's definition includes these levels plus most of the VET sector. [a] Mean reading performance in PISA 2003. [b] Mean mathematics performance in PISA 2003.

Table notes: [i] Data is presented in calendar year format. Where the data is in financial years, it is expressed in terms of the year where the financial year begins e.g. 2010-11 is shown as 2010. [ii] The 'Australia's score' field presents the Australian values used in the OECD comparisons. [iii] This is the arithmetic (simple) average of the OECD country scores. [iv] This is the arithmetic (simple) average of the top five OECD countries in a ranked list. [v] This represents Australia's distance from the frontier as defined by the average of the top five ranked OECD countries. It is calculated as 100*(Top five average - Australia's score)/Top 5 average. Where the solution is a negative value or zero, 'no gap' is shown in the cell. [vi] OECD rankings are performed on those OECD countries for which data is available. Individual data availability may vary between indicators. '-' = data not available.

Projected trends in demand for skills

An important indicator of a transition to a more innovation- or knowledge-driven economy is the shift in employment composition towards jobs that are more highly skilled. As the Australian workforce becomes more highly skilled over time, the qualification requirements within particular occupations tend to rise. The demand for qualifications is driven by industry demand, the increasing size of the labour market, changing employment composition, retirements, skills deepening and skills broadening. Official data indicates that in 2011 the share of those in the workforce holding post-school qualifications (e.g. certificate, diploma, advanced diploma, undergraduate or postgraduate) was nearly 60%.^{158 159} Modelling commissioned by AWPAs projects that by 2025 this share is likely to range from 65% to 75%, depending on a range of plausible economic scenarios.¹⁶⁰

AWPA has developed four growth scenarios for Australia to 2025 as a basis for understanding Australia's workforce needs and how these needs should be addressed.¹⁶¹ While in 2011 there were around 6.8 million employees with at least one post-school qualification in various occupations,¹⁶² by 2025 this number is projected to increase by up to 4.5 million, to 11.3 million (for the highest growth scenario).¹⁶³ Based on this modelling, by 2025, industry demand for qualifications at the diploma level or above could exceed supply by 2.8 million qualifications.¹⁶⁴

An analysis of the four scenarios reveals certain common themes. The most important of these are the need for higher level qualifications and lifting labour force participation (as a result of the ageing of Australian population).¹⁶⁵ All four scenarios implicitly recognise our economic integration with Asia. In the skills area, much attention is given to Asian language studies. Increasing the level of Asian language skills has been argued to facilitate greater integration of Australian and other Asian economies. However, there is a divergence of opinion about the relative importance of Asian language skills in the Australian workforce. A recent survey indicates that despite non-Australian businesses rating bilingual skills of the Australian workforce as a competitive advantage, Australian businesses believe this to be less important.¹⁶⁶

The importance of access to appropriate staff skills as a driver of international competitiveness is ranked very high by Australian businesses.¹⁶⁷ Interestingly, Australian respondents have ranked Australia's performance in this driver very high at 7th out of the 76 drivers, while non-Australian respondents have ranked it at 25th. In relation to their views on staff skills and business capability, non-Australian respondents, in particular, feel that there is a need to improve the skills of Australian staff and managers or, at least, improve the perceptions of them.¹⁶⁸

In the modelling commissioned by AWPAs the industries with the largest projected increase in the number of people employed by 2025 will be: Health Care and Social Assistance; Professional, Scientific and Technical Services; and Education and Training. The strongest growth in occupations to 2025 will be in Professionals, followed by Managers and Community and Personal Service Workers. There will be a million more Professionals by 2025, and Managers and Professionals will comprise 39% of the workforce. Innovative, productive and networked businesses tend to be characterised by higher quality more education management.¹⁶⁹ Improving skills utilisation is a key requirement for productivity improvement.¹⁷⁰

The trend across all scenarios is that demand for tertiary education qualifications in Australia is projected to generally outstrip supply in the years to 2025 and this demand will even be stronger in the higher growth scenarios.¹⁷¹ More precisely, the AWPAs modelling shows that the rate of projected annual growth

158 ABS (2011) *Survey of Education and Work*, cat. no. 6227.0.

159 This value (60%) that refers to percentage of the workforce holding post-school qualifications (i.e. certificate, diploma, advanced diploma, undergraduate or postgraduate) differs considerably from the indicator 'Proportion of population aged 25–64 attaining tertiary education' (from Table 3.1) which is 38% for 2011. The reason for this discrepancy is difference in the definition of tertiary education (or post school qualifications) use in Australia and the OECD. These differences are explained in the notes of Table 3.1.

160 Deloitte Access Economics (2012) *Economic modelling of skills demand and supply*, Deloitte Access Economics, Canberra, p.52.

161 AWPAs commissioned Deloitte Access Economics to undertake economic modeling which draws out the skills implications of a range of scenarios. The modeling examines both the demand for post-school qualifications (demand by industry) and the supply of new post-school qualifications (completions by domestic students and those provided through net migration). Deloitte Access Economics released Economic modeling of skills demand and supply on 2 November 2012.

162 ABS (2011) *Survey of Education and Work*, cat. no. 6227.0.

163 Deloitte Access Economics (2012) *Economic modelling of skills demand and supply*, Deloitte Access Economics, Canberra, p.56.

164 AWPAs (2013) *Future focus; National Workforce Development Strategy*, AWPAs, Canberra; the annual shortfall of people with qualifications at diploma level or above is projected to range from 108,650 to 162,485.

165 AWPAs (2013) *Future focus; National Workforce Development Strategy*, AWPAs, Canberra, p.10.

166 Enright M J (2012) *Australia's competitiveness survey Preliminary findings*, CPA Australia, Southbank, Victoria.

167 Enright M J (2012) *Australia's competitiveness survey Preliminary findings*, CPA Australia, Southbank, Victoria, pp.10–11. Note: more than 6000 business decision makers in Australia and overseas were surveyed.

168 Enright M J (2012) *Australia's competitiveness survey Preliminary findings*, CPA Australia, Southbank, Victoria, p.10.

169 Australian Government (2012) *Australian Innovation System Report—2012*, DIISRTE, Canberra, p.12.

170 AWPAs (2013) *Future Focus; National Workforce Development Strategy*, AWPAs, Canberra, p.11; see also Australian Government (2012) *Australian Innovation System Report—2012*, DIISRTE, Canberra, p.11.

171 AWPAs (2013) *Future Focus; National Workforce Development Strategy*, AWPAs, Canberra, p.11.

in industry demand for postgraduate qualifications is between 3.9% and 4.9% in the three higher growth scenarios, while for undergraduate qualifications it is between 3.3% and 4.1%.¹⁷² Industry demand for qualifications held is expected to be strongest at higher qualification levels (postgraduate, undergraduate, diploma and advanced diploma).¹⁷³ Data indicates a steady rise of the proportion of people with higher qualifications over time (Table 3.1). However it is important to recognise that the lower level Certificates can lead to more people entering the workforce, thereby increasing participation, and are pathways to higher level qualifications, especially for those experiencing disadvantage.

Annual growth in tertiary qualification completion rates of at least 3% per annum is projected to meet the needs of employers over the forecast period. Lifting completion rates is also expected to contribute to an increase in labour force participation rates from its current level of around 65% (Table 3.3). AWPA advocates a goal of 69% labour force participation. In terms of investment needed to meet industry demand for high-quality skills, AWPA estimates that public and private funding for tertiary education will need to expand by a little more than 3% per year, a rate in line with projected economic growth.¹⁷⁴

A modelling project commissioned by Google Australia argues for the potential growth prospects of the technology sector in Australia and growing demand for entrepreneurs in this sector. This modelling estimated that accelerated growth of technology start-ups could contribute up to 4% of GDP by 2033 and directly employ 540,000 people.¹⁷⁵ Based on the qualifications of current Australian tech start-up founders, the skills that appear to be most important for founding a tech start-up are computer science and business skills.¹⁷⁶

Science, technology, engineering and mathematics (STEM) skills are critical for Australia's national productivity and global competitiveness.¹⁷⁷ Innovation-active businesses are around twice as likely to use engineering skills; twice as likely to use science and research skills; and three times more likely to use ICT skills than non-innovation active businesses.¹⁷⁸ Moreover, Australian businesses introducing world-first innovations report much greater usage of science, research and engineering skills than less novel innovators (adopters and modifiers).¹⁷⁹ The declining enrolments and reduced numbers of graduates in STEM disciplines indicated in the *Health of Australian Science* Report is likely to have negative implications on the development of world-first innovations.¹⁸⁰

However, issues about supply and demand of STEM skills are complex and generalisations about the market of STEM skills may be difficult as sectors of the economy have different requirements in terms of quality and quantity of STEM skills. From the employers' viewpoint, Australian industry is experiencing difficulty in recruiting employees with STEM skills. A recent survey by the Australian Industry Group (AiG) showed that 41% of the businesses responding to the survey indicated that they had difficulty in recruiting technicians and trade workers with STEM skills, 27% in the case of professionals with STEM skills and 26% for managers with STEM skills.¹⁸¹

While this is experienced by enterprises of all sizes, it is most intensely felt by large enterprises. However, there has been some improvement over the past three years, where domestic ICT commencements have steadily increased, and this should have positive implications in future years for completions in these courses.¹⁸² With the slow growth in the numbers of undergraduates in science and engineering disciplines, recruiting skilled migrants may help address the shortfall in the short term (See Chapter 1).¹⁸³ Australia ranks 25th in the percentage of science and engineering degrees at 17.5% of total new degrees in 2010,¹⁸⁴ whereas it is estimated that 75% of the fastest growing occupations require STEM skills.¹⁸⁵ In fact, estimates indicate that demand for tertiary graduates with STEM skills will outpace supply in Australia in the next 25 years.¹⁸⁶

172 *Ibid.*

173 *Ibid.*

174 *Ibid.* p.16.

175 PwC (2013) *The startup economy: How to support tech startups and accelerate Australian innovation*, Commissioned by Google Australia, PwC, Melbourne, p.10.

176 *Ibid.* p.18–20.

177 Reid J & McLaughlin P M (2012) *Establishing STEM Educational Leadership*, Shengquan Yu (ed.) Proceedings of the 2nd International STEM in Education Conference 2012: Science, Technology, Engineering and Mathematics, Beijing China, 24–27 November, 2012, pp.241–247.

178 Australian Government (2012) *Australian Innovation System Report—2012*, DIISRTE, Canberra, p.36.

179 *Ibid.*

180 Quintini G (2011) *Over-Qualified or Under-Skilled: A review of Existing Literature*, OECD Social, Employment and Migration Working Papers No. 121, OECD Publishing; Australian Industry Group (2013) *Lifting Our Science, technology, Engineering and Maths (STEM) Skills*, Australian Industry Group, Sydney, p.3; Australian Government (2012) *Health of Australian Science*, the Office of the Chief Scientist, Canberra, p.5; Beanland D (2012) *Engineering Education: The Need for Transformation*, presentation in Melbourne on 19 July 2012.

181 Australian Industry Group (2013) *Lifting Our Science, technology, Engineering and Maths (STEM) Skills*, Australian Industry Group, Sydney, pp.3–7.

182 AWPA (2013) *ICT Workforce Issues Paper*, AWPA, Canberra, p.13.

183 Australian Industry Group (2013) *Lifting Our Science, technology, Engineering and Maths (STEM) Skills*, Australian Industry Group, Sydney, p.2.

184 OECD (2012) *OECD Economic Surveys: Australia 2012*, OECD Publishing.

185 Becker K & Park K (2011) Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education*, 12(5/6), p.23.

186 Reid J & McLaughlin P M (2012) *Establishing STEM Educational Leadership*, Shengquan Yu (ed.) Proceedings of the 2nd International STEM in Education Conference 2012: Science, Technology, Engineering and Mathematics, Beijing China, 24–27 November, 2012, pp.241–247.

The number of students enrolled in a maths major in Australian universities declined by 15% between 2001 and 2007.¹⁸⁷ Moreover, between 2001 and 2011, commencements in tertiary ICT courses declined by 53%, with completions declining by 58% in the same period. In 2011, there were 12,850 computer science graduates and 16,750 engineering graduates of which only around 4,500 (35%) and 9,350 (56%) were domestic students respectively.¹⁸⁸ The interest in studying computer science has declined, with the proportion of domestic students graduating from computer science falling by two-thirds in the last decade.¹⁸⁹ This may have been in response to students' preferences for other more promising employment outcomes.¹⁹⁰

A system based on students' demand to higher education could have the potential of increasing competition and efficiency, making the system more diverse and responsive to students' and employers' needs.¹⁹¹ The projected expansion in demand for qualifications will not be met by simply expanding the availability of places in tertiary education. It will also require a number of complementary strategies, including supporting greater participation in tertiary education from less advantaged sectors of the population; increasing the retention rate of older workers in the workforce; raising language, literacy and numeracy skills generally across the population; and enhancing the quality and flexibility of the tertiary education. Skilled migration may function as a 'swing variable' in the supply of qualifications within the labour market, although it is less important in size than the domestic completion of qualifications.¹⁹²

According to AWPA modelling, undergraduate qualifications will account for more than half of the total contribution of qualifications from net migration, while diplomas and advanced diplomas will also make up a significant component of this contribution.¹⁹³ However, the general pattern of qualification supply from net migration shows a gradual decline in the forecast period to 2025, mirroring the profile for net migration in the same period¹⁹⁴ (see Chapter 1 for further discussion of skilled migration). AWPA's projected shortfalls in skilled people will therefore have significant impact on Australia's future capacity to innovate.

Australia's international education market and Asia

A distinctive feature of economic globalisation today is advancing innovation efforts through deepening scientific and technological links with other countries. Greater cross-border research connections can play an important role in the innovation process by allowing access to a larger pool of knowledge and expertise.¹⁹⁵ Internationally mobile talent contributes to the creation and diffusion of knowledge, particularly tacit knowledge.¹⁹⁶ The increasing global mobility of international researchers and tertiary students is an indication that higher education institutions increasingly rely on links across national borders.¹⁹⁷

During the 25 years between 1975 and 2000, the global population of students enrolled outside their country of citizenship rose steadily from 800,000 to 2.1 million. This population almost doubled in the decade 2000–2010, reaching 4.3 million.¹⁹⁸ This exponential increase could suggest an acceleration of the globalisation of economies and societies. Moreover, in recent years the global student mobility has, to a great extent, mirrored regional migration patterns.¹⁹⁹ Geographic proximity certainly plays a role in regional student flows. In regions like East Asia and Oceania, the increase in student flows also reflects growing political, economic and trade links within the region. Australia is seeking to build deeper and broader education relationships with the Asian region. Given Australia's geographical advantage, Australian universities and vocational education and training (VET) institutions are well placed to benefit from the Asian century by making the most of Asia's booming tertiary education market.²⁰⁰

187 Slattery L & Perpetch N (2010) *Mathematics students in serious decline*, The Australian, 10 March 2010, <http://www.theaustralian.com.au/news/nation/mathematics-students-in-serious-decline/story-e6frg6nf-1225838901032> [accessed 26 June 2013].

188 Australian Industry Group (2013) *Lifting Our Science, technology, Engineering and Maths (STEM) Skills*, Australian Industry Group, Sydney, p.2.

189 PwC (2013) *The startup economy: How to support tech startups and accelerate Australian innovation*, Commissioned by Google Australia, PwC, Melbourne, p.20.

190 It is important to recognise that students have imperfect information about the job market and market conditions may change during the time students are enrolled in their courses.

191 Australian Government (2009), *Transforming Australia's Higher Education System*, Australian Government, Canberra; also see Bradley D, Noonan P, Nugent H, Scales B (2008) *Review of Australian Higher Education*, Final Report, Australian Government, Canberra.

192 AWPA (2013) *Submission to inquiry into the framework and operation of 457 visas*, Enterprise Migration Agreements and Regional Migration Agreements, AWPA, Canberra.

193 Deloitte Access Economics (2012) *Economic modelling of skills demand and supply*, Deloitte Access Economics, Canberra, p.92.

194 *Ibid.* p.93.

195 OECD (2011) *OECD Science and Industry Scoreboard 2011: innovation and Growth in Knowledge Economies*, OECD Publishing.

196 OECD (2010) *Ministerial report on the OECD Innovation Strategy: innovation to strengthen growth and address global and social challenges*, Meeting of the OECD Council at Ministerial Level, 27–28 May 2010, OECD Publishing, p.11.

197 Salt J (1997) *International Movements of the Highly Skilled*, OECD Social, Employment and Migration Working Paper No. 3, OECD Publishing, pp.3–4.

198 OECD (2013) *Education at a Glance 2013: OECD Indicators*, OECD Publishing, p.306.

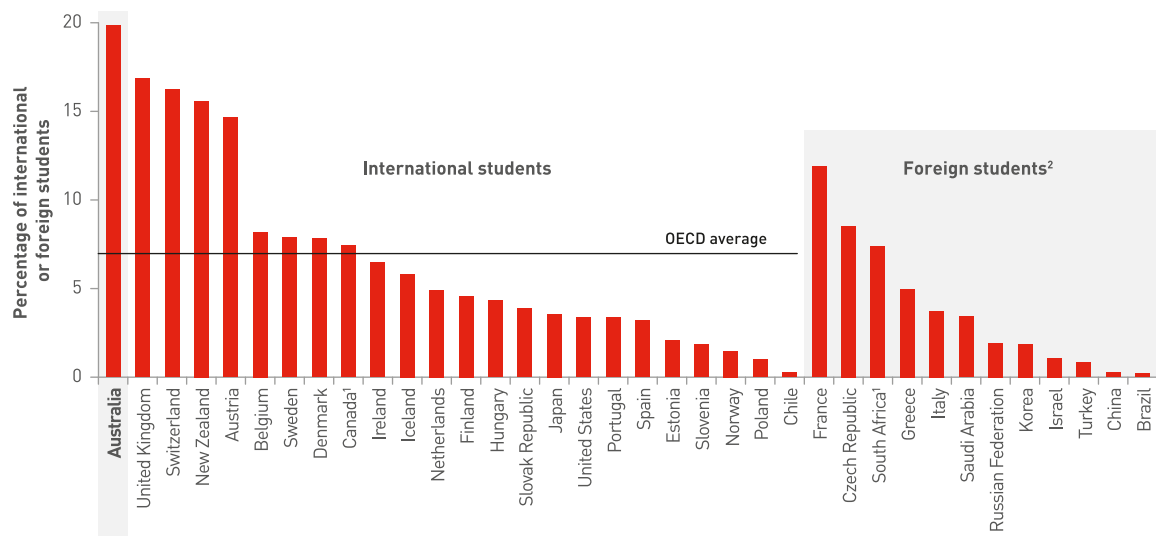
199 *Ibid.* p.363

200 Blake S (2013) *Australian Universities Improve World Standing*, news.com.au, 5 March 2013, <http://www.news.com.au/national-news/australian-universities-improve-world-standing/story-fncynjr2-1226590402495> [accessed 26 June 2013].

To grow its international education market, Australia can rely on a long history of international engagement supported by innovative policies. Other factors, such as the use of English as the language of instruction and a reputation of high quality education make Australia an attractive destination for international students. Australia's share of the international student market has grown over recent years, peaking at 7% in 2009. This has made Australia the third most popular international education destination after the US (17%) and UK (13%).²⁰¹ Although Australia has maintained a high market share, this gradually declined to 6.6% in 2010²⁰² and 6.1% in 2011²⁰³ (Table 3.1).

Australian tertiary education institutions have one of the highest shares of international student enrolments in the OECD²⁰⁴ (Chart 3.2). In 2011, international students made up 21.3% of the total student population in Australian universities; and there were as many as 402,000 foreign students in Australia in 2012.²⁰⁵

Chart 3.2 International or foreign student enrolment as a percentage of total tertiary enrolment, 2010



Sources: OECD and UNESCO Institute for Statistics for most data on non-OECD countries. Table C4.1. See Annex 3 for notes (www.oecd.org/edu/eag.htm); OECD (2013) *Education at a Glance 2013: OECD Indicators* p.31.

Note: Countries are ranked in descending order of the percentage of international or foreign students in total tertiary education. Foreign students are defined on the basis of their country of citizenship; these data are not comparable with data on international students and are therefore presented separately in the chart. International student refers to students crossing borders for the specific purpose of studying. Foreign students are non-citizens enrolled at an institution of education outside their home country.

201 OECD (2012) *Education at a Glance 2012: OECD Indicators – Country Note-Australia*, OECD Publishing.

202 OECD (2012) *Education at a Glance 2012: OECD Indicators*, OECD Publishing, p.381.

203 *Ibid.*, p.307.

204 *Ibid.*, p.311.

205 Australian Education International (2013) *Australia—Educating Globally: Advice from the International Education Advisory Council*, Australian Education International, Canberra, pp.2,8.

International education activity contributed \$15 billion in export income to the Australian economy in 2012, a 4.4% decrease from the earnings recorded in the calendar year 2011 and down 1.4% on financial year 2011–12 (\$15.3 billion).²⁰⁶ Of the total export income generated by international education activity in 2012, \$14.5 billion was from spending on fees and goods and services by onshore students²⁰⁷ and a further \$555 million was earned through offshore and other education activities. In 2011–12, the higher education sector generated around \$9.7 billion in export income (67.0% of total on-shore earnings), while the VET sector generated \$2.7 billion in earnings (18.4%). Export income from English Language Intensive Course for Overseas Students (ELICOS) was \$687 million (4.7%), schools \$592 million (4.1%), and non-award \$459 million (3.2%).²⁰⁸

While historic rates of growth in international student numbers are expected to slow somewhat, it is estimated that the most likely growth path would see Australia hosting around 520,000 students in 2020 across all education sectors and contributing around \$19.1 billion annually to the local economy. This will represent an additional 117,000 students over the 2012 level and an estimated increase of 146,000 enrolments from that year onwards.²⁰⁹

Export revenues, however, are not the only factor making foreign students valuable. International education, as one component of temporary migration to Australia, warrants particular attention for its distinct implications for the national innovation system. For instance, significant innovation and growth is possible in both offshore and online education. Moreover, trade and investment links have been shown to flow from international students.

People coming to Australian education institutions also promote people-to-people links and cross-cultural experiences that benefit Australian individuals, businesses and researchers.²¹⁰ Australian education institutions have also benefited by investing the income generated from international students' fees in better facilities, courses and support programs, and advancing research programs.²¹¹ According to the Australian Council for Private Education and Training (ACPET), international education is claimed to create more than 120,000 jobs for Australians, directly and indirectly.²¹²

While living in Australia, international students have more opportunities to develop a better understanding of the Australian society, cultures and business practices and, hence, improve their prospects in the Australian labour market.²¹³ International students who subsequently transition to the workforce are generally better adapted to, and have greater familiarity with, Australian workplace culture than other migrant workers. In 2008–09, approximately one third of skilled migrants in Australia were former international students.²¹⁴

International education contributes to our social, economic and cultural development and it will also be a key sector for our closer engagement with Asia. Australia's world-class international education and training sector makes a significant economic and cultural contribution to Australia's influence in Asia. New and innovative ways of engaging in skills transfers will help Australia integrate more quickly and deeply into Asia and prosper from increasing Asian growth and demand. Already around four fifths of all international student enrolments in Australia are from Asia. More precisely, of the total number of international student enrolments in higher education in Australia in 2012, 77% was from Asia, with the largest proportion coming from China (41%) (Chart 3.3A). Similarly, from the international student enrolments in VET in the same year, 73% were from Asian countries, with the largest percentage share coming from India (28%) (Chart 3.3B).

206 Australian Education International (2013) *Export income to Australia from international education activity in 2012*, Australian Education International, Canberra.

207 ABS uses the term 'education related travel services'.

208 Australian Education International (2013) *Export income to Australia from international education activity in 2012*, Australian Education International, Canberra.

209 Australian Education International (2013) *Australia—Educating Globally: Advice from the International Education Advisory Council*, Australian Education International, Canberra.

210 *Ibid.*

211 Adams T, Banks M & Olsen A (2011) *Benefits of international education: enriching students, enriching communities*, in Davis D & Mackintosh B (eds.), *Making a difference: Australian international education*, Newsouth Books, Sydney, pp.9–46.

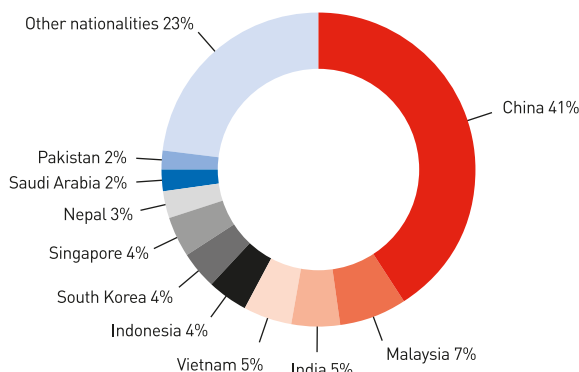
212 Australian Council for Private Education and Training (ACPET) (2011) *International Engagement – January 2011–December 2012 – Strategic Plan*, ACPET, East Melbourne.

213 OECD (2011) *OECD Science and Industry Scoreboard 2011: innovation and Growth in Knowledge Economies*, OECD Publishing.

214 Adams T, Banks M & Olsen A (2011) *Benefits of International Education: Making a Difference*, Australian Education International, Canberra.

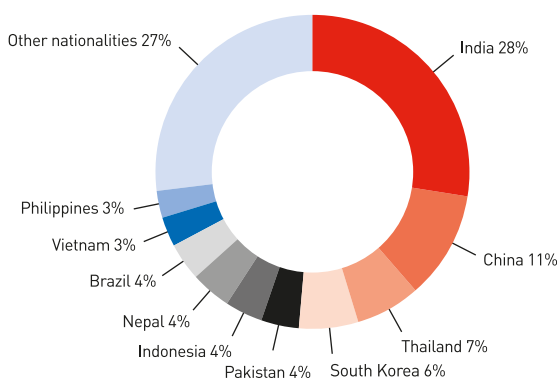
Chart 3.3 Proportion of international student enrolments in the Australian high education (panel A) and VET (panel B) sectors by top ten nationalities, 2012

A



Source: DIICCRTE (2012) International Student Data. <https://aei.gov.au/research/International-Student-Data/Pages/default.aspx>

B



Source: DIICCRTE (2012) International Student Data. <https://aei.gov.au/research/International-Student-Data/Pages/default.aspx>

Given the prevalence of Asian students among Australia's international students, enhanced three to four year work rights for postgraduate research students could help further integrate Australia and other Asian research and innovation systems. The existing skilled graduate visa (subclass 485) has already proven popular, with 38,210 visa-holders in Australia as at 31 December 2012, an increase of 74% on the previous year, with 15,550 of these from India alone²¹⁵ [See also discussion of migration in Chapter 1].

Foundation skills

An important indicator of the adequacy of national education for skills supply is a country's expenditure on broad-based education to improve literacy and numeracy skills needed for further education and work. In the Australian context, the expenditure on primary, secondary and post-secondary education climbed from 3.4% of GDP in 1995 to 4.2% of GDP in 2009, enhancing Australia's OECD ranking from 21st in 1995 to 11th in 2009²¹⁶ (Table 3.1).

'Foundation skills' (language, literacy, numeracy and employability) are the basis for learning higher and more sophisticated skills, and as a means for improved workforce participation,²¹⁷ productivity,²¹⁸ and social inclusion.²¹⁹ The inclusion of these skills in school education is essential for the development of a knowledge economy and innovative businesses.²²⁰

In the OECD Program for International Student Assessment (PISA) in 2009, Australia performed above the OECD average²²¹ (Table 3.1). However, in the Trends in International Mathematics and Science Study (TIMSS), which measures achievement in mathematics and science at Year 4 and Year 8, there was no progress in Australia's average score over the period 1995–2011.²²² The results of the 2006 Adult Literacy and Life Skills Survey has already indicated that approximately 7 million people in Australia had literacy and numeracy scores below the minimum needed 'to meet the complex demands of everyday life and work in the emerging knowledge economy'.²²³

The tertiary education system

With its high-level contribution to skills and workforce development in Australia, the tertiary education system²²⁴ plays a crucial role at a time when the Australian economy is undergoing major transformations: the mining boom; the shrinkage of manufacturing sector; the growth of services sector, the introduction of clean energy policies; the change in the demographic structure of the nation; and further economic integration into the Asian region. Australia's expenditure on tertiary education was 1.62% of GDP in 2009, ranking 11th among OECD countries ahead of countries such as France, Japan and Germany. The top five OECD countries—the United States, South Korea, Canada, Chile and Finland—averaged 2.40% in the same year (Table 3.1).

The proportion of Australia's population aged 25–64 attaining a tertiary education qualification (including university and vocational education) increased nearly 14% to around 38% between 2006 and 2011, placing Australia 9th in the OECD (Table 3.1). Among younger adults, the tertiary education attainment rate figure has been even higher. In 2011, nearly 45% of 25 to 34 year-olds had attained tertiary education, well above the OECD average of 39% for this age group.²²⁵

OECD data also indicates that tertiary education increases the likelihood of being employed in an increasingly knowledge-driven economy. On average across the OECD, 83% of 25 to 64 year-olds with a tertiary education were employed in 2010, compared with 74% of those with an upper secondary education.²²⁶ In Australia, people aged 25 to 64 holding a post-school qualification are nearly 20% more likely to be employed in the labour force than those without a qualification.²²⁷ In fact, labour market outcomes by education level reflect well on the Australian education system. The country has strong overall employment rates, with education attainment also increasing the likelihood of being employed. Unemployment rates have been low and labour force participation rates high over the last five years (Tables 2.5 and 4.3). The proportion of businesses reporting difficulty in recruiting staff and graduates has eased, along with the proportion of businesses citing lack of skilled persons as a barrier to innovation (Table 3.3).

216 OECD (2012) *Education at a Glance 2012: OECD Indicators* – Country Note-Australia, OECD Publishing.

217 AWP (2012) *Skills for prosperity: a roadmap for vocational education and training*, Discussion Paper, AWP, Canberra, p.113.

218 Coulombe S, Tremblay JF & Marchand S (2004) *International Adult Literacy Survey: Literacy scores, human capital and growth across fourteen OECD countries*, catalogue no. 89–552-MIE, Statistics Canada.

219 AWP (2012) *Skills for prosperity: a roadmap for vocational education and training*, Discussion Paper, AWP, Canberra, p.114.

220 AWP (2012) *Skills for prosperity: a roadmap for vocational education and training*, Discussion Paper, AWP, Canberra, pp.113–114; World Economic Forum (2008) *The Global Competitiveness Report 2009–2009*, World Economic Forum, Geneva, Switzerland.

221 OECD (2013) *OECD Factbook 2013: Economic, Environmental and Social Statistics*, OECD Publishing.

222 Thomson S, Hillman K, Wernert N (2012) *Monitoring Australian Year 8 student achievement internationally: TIMSS 2011*, Australian Council for Educational Research, Camberwell Victoria.

223 ABS (2008) *Adult Literacy and Life Skills Survey*, Australia; Summary Results, 2006 (reissue), cat. no. 4228.0, p.5.

224 The Australian tertiary education system consists of both higher education, with its emphasis on theoretical knowledge, and vocational education and training, which focuses on practical, technical or occupational skills for direct entry into the labour market.

225 OECD (2012) *Education at a Glance 2012: OECD Indicators* – Country Note-Australia, OECD Publishing.

226 OECD (2012) *Education at a Glance 2012: OECD Indicators*, OECD Publishing, p.120.

227 ABS (2011) *Education and work*, cat. no. 6227.0

Tertiary graduates do particularly well in the Australian labour market. As many as 88.5% of university graduates who completed a course in 2010 were employed or enrolled in further study after completing a bachelor's degree.²²⁸ This rate was 89.5% for those completing a postgraduate course. In the VET sector, 85% of 25 to 64 year-old Australians who had attained vocational education were employed in 2010, the second highest level among OECD countries²²⁹ (Table 3.2). In the same year, some 87% of those completing an apprenticeship or traineeship in the VET sector were satisfied with their training (Table 3.2), while the rate of satisfaction for non-completers was only 50%. Moreover, 80% of the VET graduates in 2012 found that training was relevant to their current job, with the satisfaction rate of graduates reaching 89% in that year.²³⁰

There is also very strong evidence that education and training makes a dramatic contribution to the capacity of the workforce to increase their earnings. On average across the OECD countries, people with tertiary education reap a substantial earnings premium in the labour market: a person with a tertiary degree can expect to earn 55% more than a person with an upper secondary or post-secondary non-tertiary education. Similarly, people who lack an upper secondary education can expect to earn 23% less than a person who has completed this level of education.²³¹

Notwithstanding the positive impact of tertiary qualifications on employment and earning rates, an OECD study indicates that the completion rates are still too low in Australia, with a negative effect on the supply of required skills.²³²AWPA has particularly emphasised the need to address non-completion of apprenticeships and traineeships and boost commencements in the VET system if industry is to have access to the skills it requires to support a growing and dynamic economy.²³³ There are cases, however, where partial completion of a qualification is considered a desired outcome, such as when an individual only wants to acquire a certain set of skills. Nonetheless, partial completion is generally categorised as non-completion and can be seen as a less than optimal use of resources.²³⁴

Trends in higher education

A total of 1,257,722 students enrolled at higher education providers in Australia in 2012, an increase of 3% from 2011. There were 934,110 domestic students in 2012, an increase of 5.1% from 2011. Domestic students represent 74.3% of all students. Public university enrolments increased 3% in 2012 to 1,171,737 students, up from 1,137,511 students in 2011. Students enrolled at public universities represent 93.2% of all students. Postgraduate students increased by 1.8% to 327,768 while undergraduate students increased by 3.6% to 891,832.²³⁵ Data indicates that in 2012, bachelor degree qualifications accounted for the greatest share in the university sector (67.6%).²³⁶ In 2012, there were 299,474 qualifications completed in the university sector, 0.7% less than completion rates of 2011 (301,560).²³⁷

Trends in vocational education

In Australia, the VET system is a major part of the tertiary education system. With close to 5,000 providers, the VET sector's high-quality vocational training will help workers and businesses take up new opportunities emerging in the economy and allow Australian businesses to improve their competitiveness in regional and global markets.²³⁸ The VET system is an important vehicle for training technicians, engineers, managers and designers who can bring about high performance workplaces, which are more likely to be innovative. Both flows and stocks of vocational skills are important to process and product improvement as more sophisticated technical skills drive businesses to adopt increasingly complex technologies to complement their stock of skills or *vice versa*.²³⁹ Many of the business management skills and trade/technician skills required for these mixed mode innovations prevalent in advanced countries²⁴⁰ come from the development of a large and skilled, vocationally trained workforce.²⁴¹ Industries

228 National Centre for Vocational Education Research (NCVER) [2012] *Tertiary education and training in Australia 2010*, NCVER, Adelaide.

229 OECD (2012) *Education at a Glance 2012: OECD Indicators – Country Note-Australia*, OECD Publishing.

230 NCVER (2012), *Australian vocational education and training statistics: Student outcomes*, NCVER, Adelaide. Note: In 2010, the rate of satisfaction with apprenticeship or training for non-completers was only 50.1%.

231 OECD (2012) *Education at a Glance 2012: OECD Indicators*, OECD Publishing, p.141.

232 Koutsogeorgopoulou V & Barbiero O (2013) *Boosting productivity in Australia*, OECD Economics Department Working Paper No. 1025, OECD Publishing.

233 AWPA (2013) *Future Focus; National Workforce Development Strategy*, AWPA, Canberra, p.119.

234 Mark K & Karmel T (2010) *The likelihood of completing a VET qualification: a model-based approach*, NCVER, Adelaide.

235 Australian Government (2013) *Students: Selected Higher Education Statistics: 2012 Student Full Year: Summary of the 2012 full year higher education student statistics*, DIICCSRTE, Canberra.

236 Australian Government (2013) *Students: Selected Higher Education Statistics: 2012 Student Full Year*, DIICCSRTE, Canberra.

237 Australian Government (2012) *Award course completions 2012: selected higher education statistics tables*, DIICCSRTE, Canberra.

238 Dalitz R, Toner P, Turpin T, (2011) *VET and the diffusion and implementation of innovation in the mining, solar energy and computer games sectors*, Centre for Industry and Innovation Studies, UWS, Penrith NSW.

239 AWPA (2013) *Human Capital and Productivity*, Literature Review, AWPA, Canberra, p.3.

240 Australian Government (2012) *Australian Innovation System Report—2012*, DIICSRTE, Canberra, p.53.

241 Toner P, Marceau J, Hall R & Considine G (2004) *Innovation agents: vocational education and training skills in the present and future Australian innovation system*, in Vocational education and training and innovation, Research readings, Dawe S ed., NCVER, Canberra, p.87.

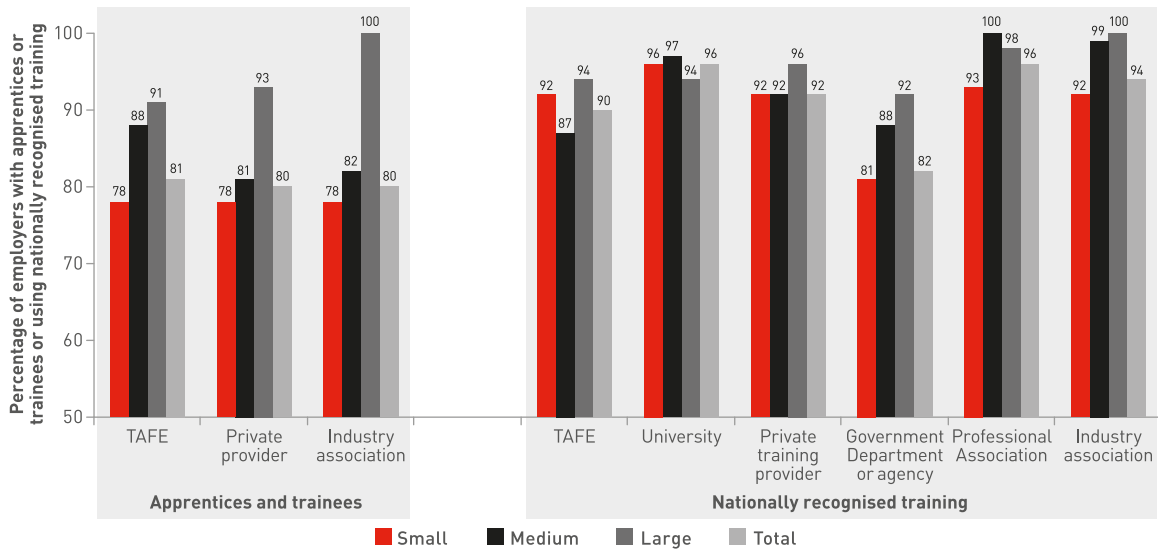
that experience comparatively rapid changes in the knowledge base of their processes and products require more intensive vocational training.²⁴²

Table 3.2 indicates a positive trend over the last five to ten years in VET enrolments, completions and employer satisfaction with the quality of VET graduates. There were 1.9 million students enrolled in the public vocational education and training (VET) system in 2012, an increase of 3.3% compared with 2011. In 2012 there were 775,500 full year training equivalents in public VET. This was an increase of 9% from 2011.²⁴³ Certificate III qualifications accounted for the greatest proportion of equivalent full-time students in the VET sector (34.0%).²⁴⁴ The number of qualifications completed in the VET system in 2011 was 521 400, an increase of 17.6% from 2010 (443,500).²⁴⁵

The proportion of all employing businesses that are satisfied with vocational training is high and ranges between 80% and 96% (Chart 3.4). Business satisfaction with the quality of this training varies with the training provider and business size. Professional and industry associations, as well as universities, have relatively high satisfaction ratings (at around 95% for nationally recognised training). For TAFE and private training providers, too, the employer satisfaction rates are high (at around 90%). As for the quality of training delivered to apprentices and trainees, business satisfaction rate on average is somewhat lower (80–81%). However, the satisfaction rates of large businesses with the quality of training provided to their apprentices and trainees are relatively high across all providers (91% to 100%).

Levels of business satisfaction with the quality of training also vary with industry sectors. For example, business satisfaction with the quality of VET education ranges from around 70% for information media and telecommunications or professional, scientific and technical services sectors to as much as 100% for the financial and insurance services, wholesale trade and electricity, gas, water and waste services.²⁴⁶

Chart 3.4 Employers who are satisfied with the quality of training delivered to apprentices/trainees or nationally recognised training delivered, by main provider, by size of business, 2011



Source: NCVER (2011) Australian vocational education and training statistics: Survey of Employer Use and Views of the VET System

242 Toner P, Marceau J, Hall R & Considine G (2004) *Innovation agents: vocational education and training skills in the present and future Australian innovation system*, in Vocational education and training and innovation, Research readings, Dawe S ed., NCVER, Canberra, p.88.

243 NCVER (2013) *Australian Vocational Education and Training Statistics: Students and Courses 2012*, NCVER, Adelaide.

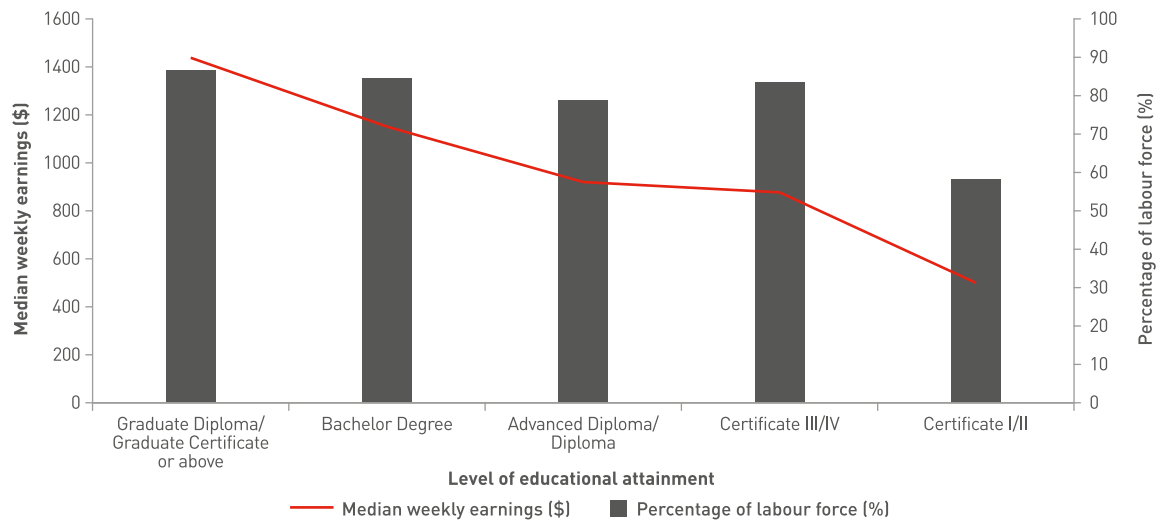
244 *Ibid.*

245 *Ibid.*

246 NCVER (2011) *Australian vocational education and training statistics: Survey of Employer Use and Views of the VET System Student outcomes*, NCVER, Adelaide.

In 2010, VET sector graduates in full-time employment in Australia earned \$48,200 per year on average, while those in full-time employment who did not complete their apprenticeship or traineeship earned \$40,700 per year on average.²⁴⁷ In 2012, VET graduates working full-time after training earned \$54,500 per year on average.²⁴⁸ The earnings premium increases with higher levels of educational attainment (Chart 3.5). This is reinforced by the fact that innovative Australian businesses use a relatively broad range of skills, such as marketing, project management, business management, finance, information technology, engineering, scientific research, trades, and machinery operation.²⁴⁹

Chart 3.5 Earnings and employment rate by education attainment (2009) (percentage of the labour force in each category)



Source: ABS (2010) Education and training experience, 2009, cat. no. 6278.0

Workplace or employer issues, lack of support and low wages are important reasons for the low completion rates for apprenticeships.²⁵⁰ Apprenticeship outcomes are expected to benefit from recent steps towards restructuring and streamlining the training packages based on nationally endorsed standards for recognising and assessing skills and qualifications.²⁵¹ For example, an effective transition from time-based to competency-based completion of apprenticeships, as well as apprenticeship mentoring programs are expected to lift completion rates.²⁵²

²⁴⁷ NCVER (2010) *Australian vocational education and training statistics Apprentice and trainee destinations 2010*, NCVER, Adelaide, p.1.

²⁴⁸ NCVER (2012) *Australian vocational education and training statistics Student outcomes 2012*, NCVER, Adelaide, p.5.

²⁴⁹ Australian Government (2012) *Australian Innovation System Report—2012*, DIISRTE, Canberra, p.36.

²⁵⁰ Australian Government (2011) *A Shared Responsibility: Apprenticeships for the 21st Century*, Final Report of the Expert Panel, DEEWR, Canberra.

²⁵¹ Australian Government (2012) *Australian Apprenticeships Reform*, DEEWR, Canberra, <http://www.australianapprenticeships.gov.au/sites/default/files/publication-documents/AustralianApprenticeshipsReform.pdf> [accessed 14 August 2013]; Australian Government (2013) *Reforming Support Services for the Australian Apprenticeships System*, Discussion Paper, Skills Connect, Canberra pp. 12–17, http://www.australianapprenticeships.gov.au/sites/default/files/publication-documents/Discussion%20Paper_0.pdf [accessed 14 August 2013].

²⁵² Australian Government (2011), *Budget 2011–12*, Treasury, Canberra.

Table 3.2 Indicators of Australia's public vocational education and training system

Indicators	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
VET system expenditure (total expenditure per adjusted full year equivalent (FYTEs)), 2011 prices (\$) ¹	-	-	-	-	12,513	12,200	11,465	11,678	10,770	-
Participation rate of Australians aged 15 years and older in VET (%) ^{2,3}	-	-	11.4	11.4	11.3	11.3	11.2	11.8	12.2	12.5
Total number of full-year training equivalents (FYTEs) undertaken in VET ('000) ^{2,3}	-	-	503	517	542	568	610	656	712	776
Number of apprentices and trainees in-training ('000) ⁴	-	-	391	396	404	415	411	436	448	455
Number of qualifications completed by students in VET ('000) ^{2,3}	-	-	296	292	319	352	394	444	521	-
Load Pass Rate for total reported VET students (%) ¹	-	-	79	79	79	80	81	81	83	-
Apprentices/trainees completion ('000) ⁴	-	-	137	142	147	155	161	169	181	191
Number of qualification equivalents completed by students in VET (Management and commerce) ('000) ¹	-	-	127	129	148	159	158	173	201	-
Proportion of graduates employed in labour force after completing VET (%) ⁵	-	-	81	82	83	82	80	78	79	78
VET graduates satisfied with overall quality of training (%) ⁵	-	-	87	87	88	88	89	88	89	89

Source: [1] NCVET (2012) *Vocational Education and Training Provider Collection, 2007-2011*. [2] NCVET (2013) *Students and Courses, 2012*. [3] NCVET (2010) *Students and Courses, 2009*. [4] NCVET (2013) *Apprentices and Trainees 2012 - Annual*. [5] NCVET (2012) *Student Outcome Surveys 2012*.

Business demand and use of the education system

There has been a steady decrease in the proportion of employers recruiting university graduates since 2008.²⁵³ This may well reflect the impact of the Global Financial Crisis (GFC) on employers' confidence and the relatively soft labour market since that time. In workplace surveys, employers routinely rank work experience as among the most important staff attributes they look for.²⁵⁴

The lack of industry experience on the part of graduates indicates the importance of industry engagement with the tertiary education system through improved partnerships.²⁵⁵ Participation in work-integrated learning has been shown to support the career development needs of individuals,²⁵⁶ in addition to being beneficial to employers through linkages with tertiary education institutions and opportunities for existing staff to gain supervisory and mentoring experience.²⁵⁷

The unmet demand for new graduates fell from around 28% in 2011 to around 18% of employers in 2012. Employers indicated that the main reason for this low percentage was the lack of appropriate candidates.²⁵⁸ The communication, technology and utilities industry recorded the highest unmet demand for appropriately qualified graduates (at around 29%), while the lowest unmet demand (at around 11%) was recorded for the construction, mining and engineering sectors. Table 3.3 shows the proportion of employers having difficulty sourcing or recruiting graduates. In 2012, around 34% of employers indicated that they had difficulty sourcing or recruiting candidates.

253 Graduate Careers Australia (2012) *Graduate Outlook 2012, the report of the Graduate Outlook Survey: Employers' perspectives on graduate recruitment*, Graduate Careers Australia, Melbourne.

254 Graduate Careers Australia (2011) *Skills employers want*, Graduate Careers Australia, Melbourne, <http://www.graduateopportunities.com/Your-Career/What-Employers-Want/> [accessed 12 June 2013].

255 AWP (2013) *Future Focus; National Workforce Development Strategy*, AWP, Canberra, p.106.

256 McIlveen P, Brooks S, Lichtenberg A, Smith M, Torjul P & Tyler J (2011) *Career development learning frameworks for work-integrated learning*, in Billet S & Henderson A (eds.), *Developing learning professionals: Integrating experiences in university and practice settings*, Springer, Dordrecht.

257 AWP (2013) *Future Focus; National Workforce Development Strategy*, AWP, Canberra, p.107.

258 Graduate Careers Australia (2012) *Graduate Outlook 2012, the report of the Graduate Outlook Survey: Employers' perspectives on graduate recruitment*, Graduate Careers Australia, Melbourne, p.4.

The proportion of graduate employers who recruited international students rose from around 16% in 2005 to a peak of around 35% in 2008, corresponding with changes to the Australian Government's General Skilled Migration program (Table 3.3). However, over the following four years the general trend was more subdued, with the 2012 rate of around 23% only slightly higher than the post-GFC years of 2009 and 2010.²⁵⁹

The majority (95%) of Australian businesses believe that the current skill levels of their staff are adequate for, or above, what is required for their operations.²⁶⁰ The size of the business does not appear to make much difference when averaged across all industries. However, the mining and electricity, gas, water and waste services sectors are less likely to report adequate staff skill levels (at around 86% and 89%, respectively).

A consistently high proportion of employers find that the employability skills of their graduate recruits meet their average expectations with 'technology', 'learning' and 'teamwork', the skills that most frequently met employers' average expectations. In a survey published in 2012, the graduate skill that most frequently exceeded average business expectations was 'learning', with 'self-management' the lowest-rated graduate skill.²⁶¹

Official data shows that over two-thirds of businesses assess their training needs informally or as needed.²⁶² There has been a significant decline in the proportion of businesses using more strategic methods such as performance management or training needs analysis in recent years—from over 45% in 2005 to around 14% in 2011 (Table 3.3). Interestingly, relatively few employers (around 3%) use new product releases to determine their training needs.

Table 3.3 Indicators of business demand and use of skilled labour

Indicators	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012
Labour force participation rate (Average) [%] ¹	63.7	63.5	64.5	64.8	65.2	65.6	65.5	65.3	65.6	65.3
Percentage of employers recruiting international students [%] ²	-	-	15.7	20.7	24.1	35.3	20.5	19	30.8	23.2
Employer difficulty sourcing/recruiting graduates [%] ²	-	-	49.3	56.5	62.4	53.5	30.7	36.3	42.1	34.3
Lack of skilled persons in any location as a barrier to innovation[%] ^{3,4}	-	-	22.8	25.7	23	19.4	20.4	20	-	-
Employer overall satisfaction with VET system [%] ⁵	-	-	71.1	-	73.9	-	77.9	-	78.1	-
Businesses reporting some or a lot of difficulty in recruiting staff (% of all employers) ⁶	-	-	40.6	-	44.4	-	33.7	-	32.3	-
Employers who use new product releases to determine training needs (% of all employers) ⁶	-	-	7.1	-	3.2	-	3	-	3.5	-

Source: [1] ABS (2013) *Labour Force, Australia*, cat. no. 6202.0. [2] Graduate Careers Australia (2012) *Graduate Outlook Survey*. [3] ABS (various) *Business Characteristics Survey*, cat. no. 8167.0. [4] ABS (2012) *Innovation in Australian Business, 2010-11*, cat. no. 8158.0. [5] NCVET (2012) *Vocational Education and Training Provider Collection, 2007-2011*. [6] NCVET (2011) *NCVER Survey of Employer Use and Views of the VET System, 2011*.

259 Employers of domestic graduates indicated that they did not employ international graduates due to a requirement for a candidate to be a citizen or permanent resident of Australia and/or because there were enough suitable local candidates.

260 NCVET (2011) *Australian vocational education and training statistics: Survey of Employer Use and Views of the VET System Student outcomes*, NCVET, Adelaide.

261 Graduate Careers Australia (2012) *Graduate Outlook 2012*, the report of the Graduate Outlook Survey: Employers' perspectives on graduate recruitment, Graduate Careers Australia, Melbourne.

262 NCVET (2011) *Australian vocational education and training statistics: Survey of Employer Use and Views of the VET System Student outcomes*, NCVET, Adelaide.

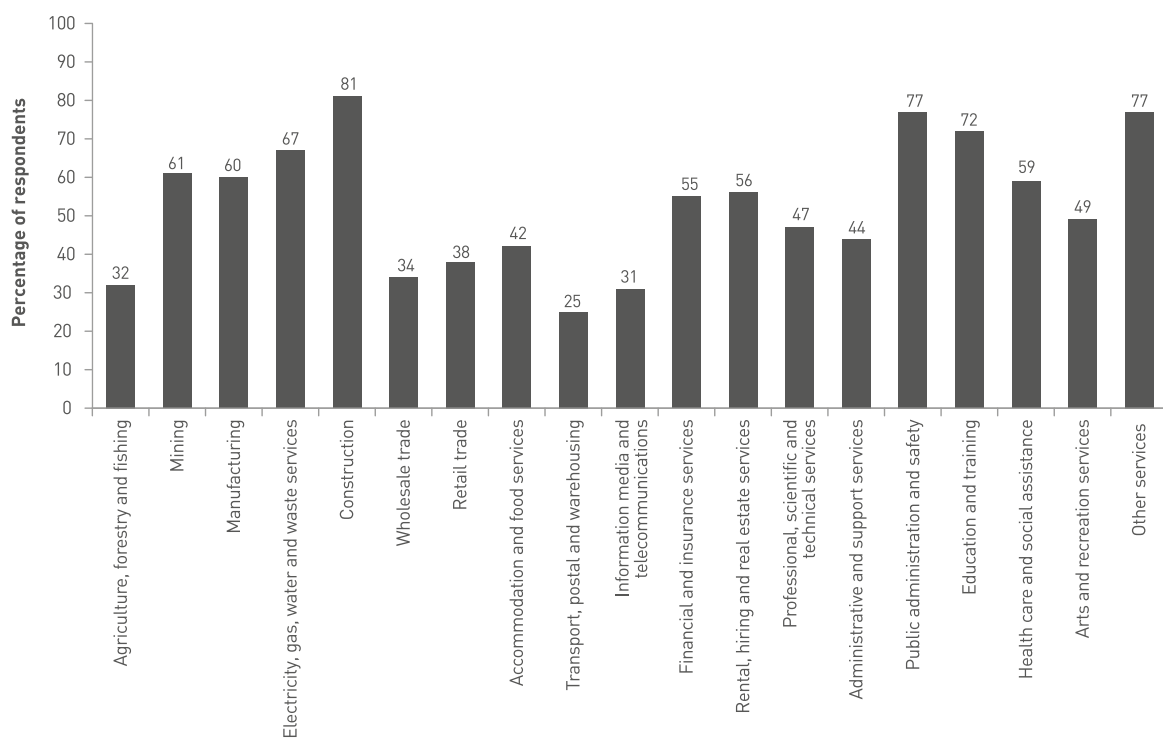
When skills needs are identified, the proportion of employing businesses experiencing some, or a lot of, difficulty recruiting staff was moderate in 2011 (at around 32%). Trend data indicates an easing in this indicator since 2005 in line with an easing in 'lack of skilled persons' as a barrier to innovation (Table 3.3). The most frequently reported reason for difficulty recruiting staff was a shortage of skilled people within the industry (at around 54%).²⁶³

Larger businesses are more likely than SMEs to identify some difficulty in recruiting staff. This increase is in the proportion of businesses experiencing some difficulty rather than any noticeable increase in businesses experiencing a lot of difficulty (approximately 15–20% across all business size classes). The mining sector (at around 51%) and the accommodation and food services sector (at around 50%) experience difficulties in recruiting staff more frequently than other sectors.

In 2011, around 54% of employing businesses had used the VET system in the previous 12 months to train their staff, compared with around 76% of businesses which used informal training systems. The larger a business, the more likely it is to have used the VET training system in the previous 12 months, with the percentage of small, medium and large businesses being around 48%, 72% and 91%, respectively. This size effect has remained relatively static since 2005.

In terms of the likelihood of businesses using VET for training their workforce, there is significant variation across industry sectors due to structural characteristics and the nature of work being undertaken (Chart 3.6). Businesses in the construction sector, for example, were the most likely to have used the VET system for training in 2011 (at 81%).

Chart 3.6 Employing businesses using the VET system for training in the last 12 months, by industry sector, 2011

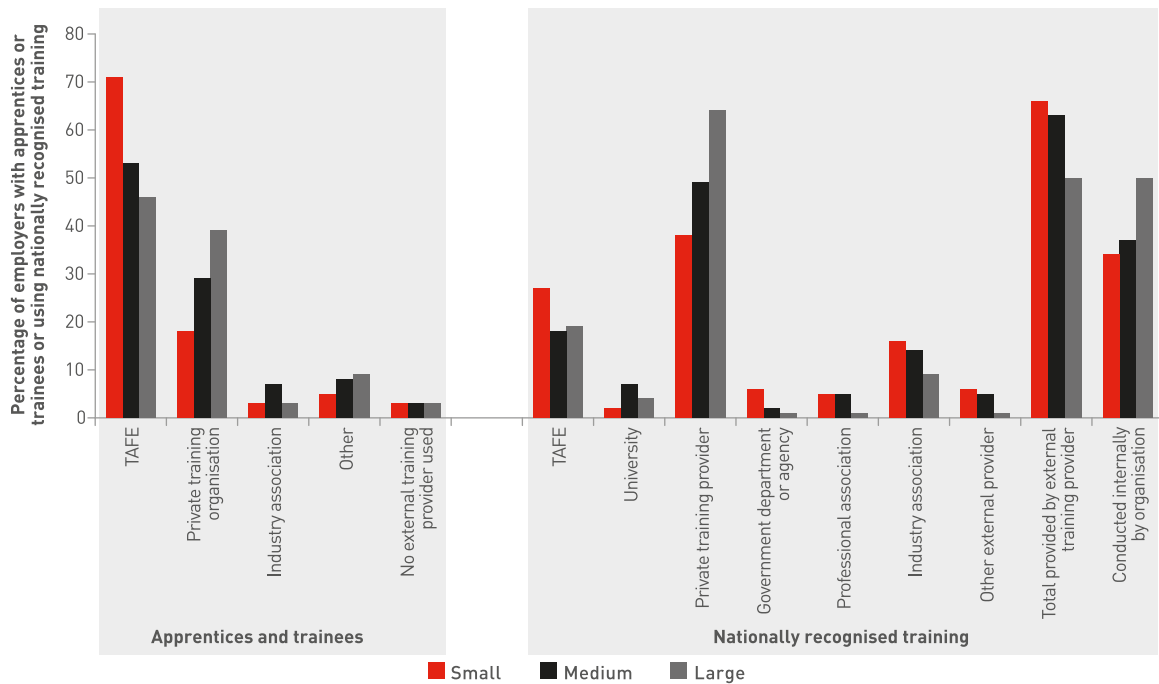


Source: NCVET (2011) Australian vocational education and training statistics: Survey of Employer Use and Views of the VET System

²⁶³ NCVET (2011) *Australian vocational education and training statistics: Survey of Employer Use and Views of the VET System Student outcomes*, NCVET, Adelaide.

The majority of businesses use TAFE institutions to train apprentices and trainees (Chart 3.7). There is, however, a strong effect of business size. Large businesses are much more likely to use private training organisations than are SMEs. The majority of businesses use private training providers or undertake nationally recognised training. Large businesses are much more likely to conduct nationally recognised training internally.

Chart 3.7 Type of provider used to conduct the majority of formal training for apprentices/trainees or nationally recognised training in the last 12 months, by business size, 2011



Source: NCVET (2011) Australian vocational education and training statistics: Survey of Employer Use and Views of the VET System

FEATURE: VOCATIONAL EDUCATION AND INNOVATION**By Gavin Moodie, Principal Policy Adviser, RMIT**

This feature argues that vocational education has a crucial role as an innovation intermediary in meeting the second national objective established by the Asian century white paper: 'Australia will have an innovation system, in the top 10 globally, that supports excellence and dynamism in business with a creative problem-solving culture that enhances our evolving areas of strength and attracts top researchers, companies and global partnerships'²⁶⁴.

Current understandings

Vocational education's contribution to innovation is usually considered to be, and restricted to, training skilled workers. Thus, Karmel's²⁶⁵ feature in the *Australian innovation system report – 2012* is on skills and the productivity challenge and most of the research readings on *Fostering enterprise: The innovation and skills nexus*²⁶⁶ are about the importance of skills to innovation and developing the capacity of current and new workers to contribute to innovation. Stanwick²⁶⁷ states the standard position succinctly: 'The underlying skills and knowledge of a vocation are the foundations for innovative practice' (p.4) and 'VET [vocational education and training] can assist the innovative process by providing specific skills but, more importantly, it should help the individual to "learn to learn"' (p.6).

This is consistent with the conventional, although now increasingly superseded, understanding of innovation as proceeding from scientific research to development and then to application in production. This linear understanding of innovation coincides with the view that government action on innovation should be restricted to correcting market failure, normally by filling gaps in the innovation supply chain. These gaps are normally understood to be at the start of the chain where government funding is needed to support research which has high externalities or non-excludable benefits and subsequently to bridge the 'valley of death'²⁶⁸ from when a development becomes too applied for research funding and not specific enough for it to be funded by business. On this understanding vocational education's role in innovation is only to equip business' workers with the skills needed to implement the innovations ultimately sourced from research. This is an outcome of universities' capture of innovation policy which results in Government funding being slanted to supporting research and development to the detriment of supporting the diffusion of innovation²⁶⁹. Even for business two-thirds of the Government's support for innovation is devoted to research and development rather than improving the problems of connectivity within the national innovation system found by the Cutler review²⁷⁰.

Toner and Dalitz²⁷¹ found that even this understanding of vocational education is mostly missing from key policy documents on Australian innovation in the decade before 2012. They reviewed the Australian government's main innovation policy statements from 2001 to 2011 to find that vocational education and vocational occupations are not considered substantively in most documents. Even when they state an important role for vocational education it is considered in isolation from other parts of the national innovation system. Accordingly, policies don't propose action to increase vocational education's contribution to national innovation²⁷²: vocational

264 Australian Government (2012) *Australia in the Asian Century white paper*, Canberra, Australia p137.

265 Karmel T (2012) *Skills and the productivity challenge*, DIISRTE (2012) *Australian innovation system report – 2012*, pp31–33, www.innovation.gov.au/aisreport [Accessed 12 April 2013].

266 Curtin P, Stanwick J & Beddie F (Eds) (2011) *Fostering enterprise: the innovation and skills nexus – research readings*, NCVER, <http://www.ncver.edu.au/publications/2367.html> [Accessed 16 April 2013].

267 Stanwick J (2011) Innovation: its links with productivity and skill development – at a glance, NCVER, <http://www.ncver.edu.au/publications/2424.html> [Accessed 16 April 2013].

268 Branscomb LM & Auerswald PE (2002) *Between invention and innovation. An analysis of funding for early-stage technology development*, report prepared for Economic Assessment Office Advanced Technology Program National Institute of Standards and Technology Gaithersburg, MD 20899-4710, p35, <http://www.atp.nist.gov/eao/gcr02-841/gcr02-841.pdf> [Accessed 27 April 2013].

269 Moodie G (2004) *Optimising tertiary education for innovating Australia*, In Marsh I (Ed) *Innovating Australia*, Committee for the Economic Development of Australia, Melbourne, p95, http://www.academia.edu/3395041/Optimising_tertiary_education_for_innovating_Australia [Accessed 27 April 2013].

270 Dodgson M, Hughes A, Foster J & Metcalfe S (2011) Systems thinking, market failure, and the development of innovation policy: the case of Australia, *Research Policy* 40: 1145–1156.

271 Toner P and Dalitz R (2012) Vocational education and training: the terra incognita of innovation policy, *Prometheus: Critical Studies in Innovation* 30: 411–426.

272 Toner P and Dalitz R (2012) Vocational education and training: the terra incognita of innovation policy, *Prometheus: Critical Studies in Innovation* 30: 411–426.



education's contribution to innovation is assumed to be self-activating, or to respond to others' initiative, vocational education being 'industry led'²⁷³. Consequently Toner and Dalitz found that vocational education's only representation on the three key national innovation advisory bodies (the Prime Minister's Science, Engineering and Innovation Council, the Co-ordination Committee on Innovation and eight industry innovation councils) was the Australian Government minister responsible for tertiary education.

Complex-evolutionary understanding of innovation

Dodgson and colleagues²⁷⁴ describe three stylised approaches to national innovation: the free market based on the work of Baumol²⁷⁵, government coordination or the 'developmental state'²⁷⁶ based on List²⁷⁷ and the complex-evolutionary system based on Schumpeter's work²⁷⁸. This understands national innovation to be an evolving complex system which has multiple contributions and connections. Dodgson and colleagues argue that Australian national innovation policy has changed from free market to complex-evolutionary system. They argue that this posits a different role for government:

It is not market failure that is the concern but the 'market creation' that is necessary to permit economic evolution to occur. The main threat is 'system failure' where there is inadequate promotion of innovation and business model experimentation. In the complex evolutionary approach, government does not just leave things to the 'free market' yet it does not 'pick winners' either. From its preeminent position it can play the role of connector by its support of dynamic and evolving national institutions and infrastructure, and through its programs encouraging the development of organisational skills and capabilities.

'Our analysis supports the argument for the continuing need for policy prescriptions that encourage building the institutional framework and organisational capabilities to better connect National Innovation Systems.'²⁷⁹

However, within the broad complex-evolutionary understanding of innovation remnants of the linear innovation supply chain remain in the Australian Government's industry and innovation statement. This announces the establishment of ten industry innovation precincts which 'will ensure that there is better [use] of Australia's research capability through strengthening business access to research expertise, encouraging mobility of researchers, and innovative approaches to fostering collaboration between businesses and the publicly funded research sector'²⁸⁰. Innovation precincts will include vocational institutes, but the statement doesn't give their role. The statement observes that there is a need for stronger and more systemic links between the university and business sectors to share personnel and expertise which it plans to address through the compacts process in which government officials discuss with each university their contribution to national policy.

While bringing universities and business closer together is commonly prescribed in Australian innovation policy and in other areas, it is likely to further reduce Australia's conduct of pure research which has fallen substantially over the last 15 years and it has the familiar risk of reducing universities' critical, independent approach to research and other activities. Even if universities were desirable and effective innovation intermediaries for big businesses, they are unlikely to be effective intermediaries for small and medium sized businesses.

273 Hawke G (2002) Industry-led VET: a partnership with local industry? *Training Agenda* 10: 13–15.

274 Dodgson M, Hughes A, Foster J & Metcalfe S (2011) Systems thinking, market failure, and the development of innovation policy: the case of Australia, *Research Policy* 40: 1145–1156.

275 Baumol WJ (2002) *The free-market innovation machine: analysing the growth miracle of capitalism*, Princeton University Press, Princeton, NJ.

276 Johnson CA (1994) *Japan: who governs? – The rise of the developmental state*, WW Norton & Company, New York.

277 List F (1841) [1909] *The national system of political economy*, Lloyd SS (trans), Longmans, Green and Co, London.

278 Schumpeter J (1942) *Capitalism, socialism and democracy*, Harper & Brothers, New York.

279 Dodgson M, Hughes A, Foster J & Metcalfe S (2011) Systems thinking, market failure, and the development of innovation policy: the case of Australia, *Research Policy* 40: 1145–1156.

280 Australian Government (2013) *A plan for Australian jobs*, <http://www.aussiejobs.innovation.gov.au/Pages/default.aspx> [Accessed 16 April 2013]





Vocational institutes as innovation intermediaries

TAFE institutes are the best bodies to stimulate 'the timely take up, modification, and marketing of knowledge solutions that already exist but need to be adapted to local environments' that is the source of much innovation²⁸¹. This is because much of TAFE institutes' work is developing the skills of the existing workforce, engaging with enterprises' production processes rather than with their less well developed research and development processes. TAFE institutes are located not only in the major city centres but are also widely dispersed throughout city fringes, regions and rural areas which are major sites of production. Even were universities the best innovation intermediaries, no country can afford to maintain research-intensive universities and public research organisations in all such centres²⁸².

Vocational institutes have similar roles in other countries. Rosenfeld²⁸³ argues that in the US 'community colleges are particularly helpful to small and midsized enterprises, since they are better positioned to reach them than universities, consultants, and service agencies, many of which prefer not to bother with "know-how" needs that may not be technologically challenging or of a scale that can be sufficiently profitable'. National Research Council Canada's²⁸⁴ digital technology adoption pilot program engages community colleges to support small and medium sized enterprises in Canada to adopt digital technology and build digital skills. In the German state (*Land*) of Baden-Württemberg, which has one of the densest concentrations of advanced manufacturing in the world, vocational schools (*Berufsschulen*) and vocational academies (*Berufsakademie*) have important roles as technological intermediaries with universities of applied sciences (*Fachhochschulen*), Fraunhofer institutes and Steinbeis transfer centres and transfer institutes²⁸⁵.

Conclusion

The Asian century white paper's national objective for Australia to have an innovation system in the top 10 globally has mostly been interpreted by the Australian Government as developing a complex-evolutionary national innovation system. On this understanding the role of government policy is to 'encourage building the institutional framework and organisational capabilities to better connect National Innovation Systems'²⁸⁶. However, many of the Australian Government's funding decisions over the last decade reflect the linear supply chain understanding of innovation where the aim is to link university research with business application^{287,288} and reflects universities' capture of innovation policy and much innovation funding.²⁸⁹

While vocational education's role in developing workers' skills and hence business' capacity to innovate is now well established, other countries have supported vocational institutes' roles in transforming practices in their communities and in incorporating existing knowledge into productive activity. This offers potential for Australian policy makers to expand the role of TAFE institutes to increase and improve connections within Australia's national innovation system.

281 Gibbons M (2004) *Globalisation, innovation and socially robust knowledge*, In King R (Ed), *The university in the global age*, Palgrave Macmillan, Houndsmills.

282 Moodie G (2006) Vocational education institutions' role in national innovation, *Research in Post-compulsory Education* 11: 131-140.

283 Rosenfeld SA (1998) *Community college/cluster connections: specialization and competitiveness in the U.S. and Europe*, Teachers College, Columbia University, New York.

284 National Research Council Canada (2012) *An overview for colleges*, http://www.nrc-cnrc.gc.ca/eng/irap/dtapp/dtapp_fs_col.html [Accessed 9 April 2013]

285 Moodie G (2006) Vocational education institutions' role in national innovation, *Research in Post-compulsory Education* 11: 131-140.

286 Dodgson M, Hughes A, Foster J & Metcalfe S (2011) Systems thinking, market failure, and the development of innovation policy: the case of Australia, *Research Policy* 40: 1145-1156.

287 Dodgson M, Hughes A, Foster J & Metcalfe S (2011) Systems thinking, market failure, and the development of innovation policy: the case of Australia, *Research Policy* 40: 1145-1156.

288 Toner P and Dalitz R (2012) Vocational education and training: the terra incognita of innovation policy, *Prometheus: Critical Studies in Innovation* 30: 411-426.

289 Moodie G (2004) *Optimising tertiary education for innovating Australia*, In Marsh I (Ed) *Innovating Australia*, Committee for the Economic Development of Australia, Melbourne, p95, http://www.academia.edu/3395041/Optimising_tertiary_education_for_innovating_Australia [Accessed 27 April 2013].

Case Studies

CASE STUDY: PRIME MINISTER'S AUSTRALIA ASIA SCHOLARSHIPS

The Australia Awards are prestigious international scholarships and fellowships funded by the Australian Government. The Prime Minister's Australia Asia Scholarships, part of the Australia Awards initiative, aim to develop internationally-aware and skilled future leaders and to establish enduring education and professional linkages between Australia and Asia.

Each year, the Prime Minister's Australia Asia Scholarships support 40 high-achieving Australian students to undertake study and internships in Asia and 20 recipients from participating countries to undertake study and internships in Australia.



Caption: 2013 Prime Minister's Australia Asia Award Holder, Glen Burton

Image provided by Janita Holt

University of Newcastle PhD candidate Glen Burton was the recipient of a 2013 Prime Minister's Australia Asia Scholarship.

Glen's PhD in civil engineering is focused on the development of fundamental soil mechanics principles that can be applied to both saturated and unsaturated soils.

Soil mechanics theory deals with the physical, mechanical and hydraulic behaviour of soils and seeks geotechnical solutions that safeguard the stability and life-long serviceability of structures, such as bridges and buildings.

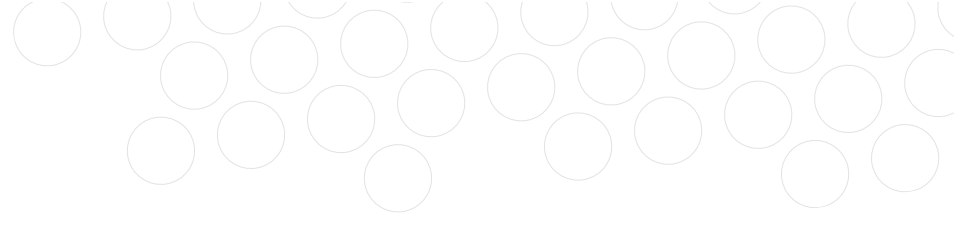
"Classical soil mechanics primarily focuses on soils that are saturated with water," said Glen.

"In practice, soils are typically unsaturated and exhibit complex deformation, strength and hydraulic behaviours. These complex behaviours can have significant impacts on society, from large destructive landslides triggered by rainfall, to damage to residential house foundations from wetting and drying."

The Prime Minister's Australia Asia Scholarship will enable Glen to spend 12 months undertaking research at Nagoya Institute of Technology in Japan, where researchers are also actively engaged in both unsaturated soil laboratory testing and constitutive modelling.

"I believe that my research on unsaturated soils will be one step further towards the routine implementation of unsaturated soil mechanics principles into engineering practice, resulting in safer and more economical infrastructure design," said Glen.





Caption: 2012 Prime Minister's Australia Asia Incoming Postgraduate Award Holder, Vidhyasri Subramaniyam

Image provided by Janita Holt

Vidhyasri Subramaniyam received a 2012 Prime Minister's Australia Asia Scholarship.

Vidhyasri holds a Bachelor of Science in Agriculture and a Master of Science in Agricultural Microbiology from Tamil Nadu Agricultural University (TNAU) in Coimbatore, India. Prior to commencing her Prime Minister's Australia Asia Scholarship, Vidhyasri was employed as a researcher in the Department of Agricultural Microbiology at TNAU.

Vidhyasri has previously been awarded a number of academic awards and her work has been published in a variety of journals, including the *Journal of Basic and Applied Scientific Research* and the *International Journal of Tropical Agriculture*.

Under her Australia Award, Vidhyasri is undertaking a PhD in the Centre for Environmental Risk Assessment and Remediation at the University of South Australia. Her research focuses on the synthesis and assessment of nano-scale iron particles for remediation of chromium (a toxic heavy metal contaminant) that pollutes soil and water in our ecosystem. It is expected the research will assist in developing new environmental remediation technologies that target chromium contaminated soil and water in our ecosystem.

CASE STUDY: COLLABORATION AND SHARING OF KNOWLEDGE IN SKILLS STANDARDS DEVELOPMENT



Caption: Members of SSA and NSDC meet in 2010 to discuss the Skills Council model

Image provided by SSA

This collaborative effort between Service Skills Australia, the Industry Skills Council for the Service Industries, and the Retailers Associations Industry Skills Council of India, in partnership with the National Skills Development Council of India has increased understanding between the participating councils of the benefits and value of shared understandings.

India faces a significant challenge to address the skills capital requirements that are needed to develop their national economy. The Indian Government provided the catalyst for industry to implement a national, industry driven solution to addressing its skilled workforce needs by creating the National Skills Development Corporation (NSDC), which in 2010 invited Service Skills Australia (SSA) to visit India and meet with industry representatives in order to explain the Australian Industry Skills Council model.

NSDC requested SSA's assistance in two specific areas:

- supporting the formative sector skills councils in their initial deliberations including relevance, scope, industry and sector composition, partners, leadership, governance, initial undertakings, engagement strategies, competency frameworks, and sustainability
- supporting the NSDC and its roles and execution of responsibilities, standards and competency frameworks, engagement with multiple ministries, and models promoting 'scalability'.

At this stage, although the concept of sector skills councils was being discussed and promoted, none had been approved. There are now 16 sector skills councils operating in India, due at least in part to the role of SSA in helping industry stakeholders understand the concept.

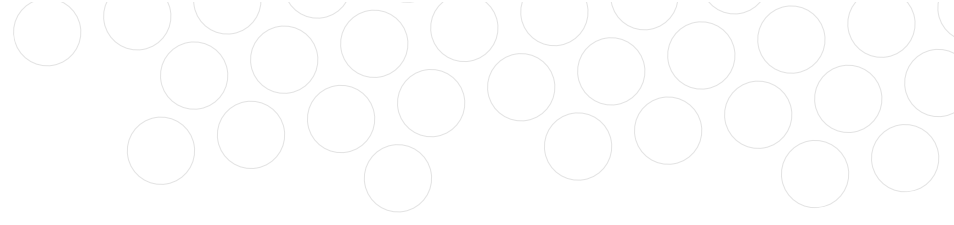
As another result of the success of the visit, the Australian Government and the NSDC included further activity in their ongoing strategies in the skills and workforce development areas. Those activities include the partnerships and collaborative work being undertaken with the Australian Industry Skills Councils and the emerging Sector Skills Councils of India.

On the 26th of May 2012, SSA commenced what will be a two part project with the Retailers Associations Skills Council of India (RASCI) to assist in the development and building of their Skills Council.

SSA provided RASCI with guidance, mentoring and expert advice on:

- Industry consultation processes (stakeholder engagement)
- Standards development
- Ensuring linkages and adherence with broad deliverables of the National Skill Development policy.





This first stage of this project saw:

- A shared understanding of the framework for occupational skills standards development, leading to easier recognition of skills for international mobility purposes.
- The drafting of skill templates, quality assurance processes, stakeholder engagement strategies and qualification/skill descriptors for eight job roles in the Indian retail sector.

While this work was carried out in alignment to the Australian system, this was not a duplication of the Australian system for Indian Industry. The consultation process ensured that the product being developed was tailored to the needs of Indian industry, delivering a bespoke outcome.

Monitoring and further coaching will need to be provided to ensure that there is follow-through on the outcomes of this first stage of work. A second visit will take place in April 2013 to refine the work completed so far and to further develop industry engagement strategies.

The support provided by this consultancy work is a crucial service provided by Australia that adds value to the economy of India and also the relationship between our two countries. This was achieved through the provision of expertise, knowledge and in-depth understanding through SSA.



CASE STUDY: COMMITMENT TO LANGUAGE, LITERACY AND NUMERACY TRAINING PAYS DIVIDENDS FOR ADELAIDE MANUFACTURER



Caption: Operator using the pick and place machine



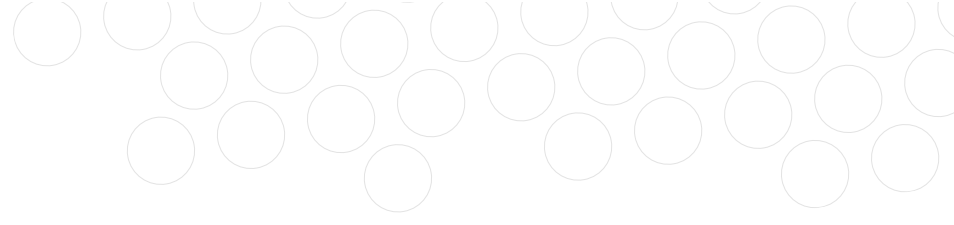
Caption: Workers at Redarc Electronics' production facility south of Adelaide.

Images provided by Redarc Electronics

An Adelaide manufacturing company, Redarc Electronics Ltd, has credited committing to employee training under the Workplace English Language and Literacy (WELL) program for a remarkable turnaround.

Redarc's Managing Director Anthony Kittel said the business was enjoying "some impressive employee statistics" after delivering language and literacy training to most of its employees in the past two years.





WELL is an Australian Government program that assists businesses to develop their employees' English language, literacy and numeracy skills. Redarc partnered with TAFE SA Adelaide South Institute to develop a program of training that was vocationally relevant and tailored to the needs of their organisation.

Mr Kittel and his wife Michele bought Redarc in 1997 when it was run down and had only eight employees. The new owners realised that creating an environment of learning and growth was essential to future success. "I am pleased to say that due to our focus on developing a highly skilled and empowered workforce we have experienced excellent growth in our business."

"We now employ 95 staff, and we are proud that we are one of the largest advanced manufacturers in the state. Today our [employees] understand clearly where we're going. I am truly passionate about developing our people."

Most production workers at Redarc are early school leavers from lower socio-economic and non-English speaking backgrounds. Several years ago some apprentices were struggling with mathematics and at risk of not completing their apprenticeships. "Our management sought out assistance for them and approached TAFE SA Adelaide South Institute. It was through this collaboration that the WELL program was implemented at Redarc."

Mr Kittel said 50 employees completed WELL training in the first year and 75 are now in training. The course includes communicating for success, quality products, literacy and numeracy, statistical process control, computing and Excel skills, occupational health and safety and supervision for team leaders.

He said there were many highlights from training outcomes. Employees had become accredited, there was a greater participation in consultation, employees were taking responsibility, they were building knowledge and skills and a better understanding of the business, and featuring improved communication and documentation. Sick days had fallen to 2% and daily attendance rates rose to 97%.

"The result of a great working environment and investment in our people through training and enhancement of skills has led to some impressive employee statistics," he said. Women now form 44% of management, average employment is for five years and average sales growth has reached 28% over four years.

Redarc has a five-year strategy to expand the business from a \$20 million a year operation to \$50 million by 2017. Mr Kittel sees this as a collaborative process: "this will only be possible with a highly skilled workforce and our continued partnerships and collaboration with Government, industry bodies, universities, and training organisations to provide foundation skills training that is responsive to our business needs and the wider economy."

CHAPTER 4: PUBLIC RESEARCH CAPACITY AND INNOVATION

The preceding chapters have argued that collaborative innovation and workforce development are vital to making Australia a productive, prosperous, and resilient nation that is well integrated with the global knowledge economy. This chapter will discuss the role of research in enhancing the performance of Australia's national innovation system.

Research engagement with Asia

International research collaboration allows a critical mass in infrastructure and human resources to be applied to large-scale or 'wicked' problems that no one nation has sufficient capability on its own to address.²⁹⁰ International collaboration is also a major driver of research quality.²⁹¹ Research links with Asian countries complement Australia's growing engagement with Asia in tertiary education (See Chapter 3). Research links can also strengthen bilateral political and economic ties leading to increasing commercial links (see Chapter 1) and other mutually beneficial opportunities. Joint research engagement also helps keep Australia abreast of the future directions of Asian innovation and Asia's rapid socio-economic transformation. Chapter 1 showed growing trade and innovation engagement between Australia and the rest of Asia. Australia's research engagement is one aspect of the innovation system that has shown early and rapid integration with other Asian innovation systems.

Australia's research engagement with China has broadened significantly over the last three decades since the signing of a treaty on science cooperation in 1980. The relationship has grown from aid and development-oriented initiatives to a wide range of mutually beneficial research collaborations.²⁹² The proportion of Australian scientific publications with a Chinese co-author rose more than ten-fold over the 15 years to 2010, with China becoming Australia's third ranked science publication partner.²⁹³ Correspondingly, Australia was China's sixth ranked partner for collaboration, higher than would be expected based on Australia's global rank as the twelfth largest producer of scientific papers.²⁹⁴

The areas with the highest numbers of Australia-China joint publications have been in the sciences and engineering, including mathematical sciences, technology, chemical sciences, physical sciences and earth sciences. Australian joint publications with international collaborators have a higher average citation impact than is the case for publications by Australian authors without an international collaborator.²⁹⁵ Since 2006, the Chinese Academy of Sciences has been the top international institution partner organisation for Australian authors.²⁹⁶

The level of collaboration between Australian researchers and their counterparts in other Asian countries has also improved. Australian collaboration in science with Japan is growing more slowly than with China, but joint publications still rose by 59% over the decade to 2010, with Australia ranking as Japan's ninth highest publication partner.²⁹⁷ This is a significant achievement as Japan is an established world leader with the fifth largest number of scientific publications and the second largest number of triadic patent families granted worldwide in 2009.

Australia is India's tenth highest partner for joint publications, with the number of joint publications growing from a low base by 450% over the decade to 2010.²⁹⁸ Australia-India research collaboration is more than keeping pace with the overall growth in India's scientific output. Shared challenges in the areas

290 Australian Government (2012) Health of Australian Science, the Office of the Chief Scientist, Canberra.

291 Australian Government (2011) Australian Innovation System Report 2011, Department of Innovation, Industry, Science and Research, Canberra, p89

292 Australian Government (2011) Science and Research Collaboration Between Australia and China, DIISRTE, Canberra, p.3.

293 Thomson Reuters (2011) Data from Web of Science, May 2011; China has been Australia's third ranked partner since 2008 and the latest Thomson Reuters data indicate that it has retained this position until well into 2013.

294 Australia and China currently share four of their top five other partners (United States, United Kingdom, Germany and Canada). The percentage of Australian papers with a Chinese co-author rose from 0.57% of papers in 1996 to 6.15% in 2010. The fields of research with the highest numbers of Australia-China joint publications are the sciences and engineering, including mathematical sciences, technology, chemical sciences, physical sciences and earth sciences.

295 Australian Government (2011) Science and Research Collaboration Between Australia and China, DIISRTE, Canberra.

296 Thomson Reuters (2011) Data, DIISRTE analysis.

297 Thomson Reuters (2011) Data from Web of Science, May 2011.

298 Thomson Reuters (2011) Data, DIISRTE analysis.

of food and water security, health and the environment provide a strong basis for collaboration between Australian and Indian researchers.

Fuelled by one of the highest global rates of investment in research and development as a proportion of GDP (3.74% in 2010), South Korea accounted for the fifth largest number of triadic patent families granted worldwide in 2009. South Korea has dramatically expanded its scientific output over the past 15 years, with Australia ranking as its ninth most frequent partner for international collaboration.²⁹⁹

Australia also has close science and research ties with its South East Asian neighbours, including Singapore, Thailand, Malaysia, Indonesia and Vietnam. While a comparatively small country, Singapore has shown a major increase in innovation performance over the decade to 2010, with Australia ranking as its third largest publication partner.³⁰⁰ Singapore has a highly dynamic economy and has been collaborating with Australia in a number of niche science and research areas of mutual interest, including medical research.³⁰¹

While the scientific impact of Malaysia, Thailand, Indonesia and Vietnam is relatively modest, Australia has comparatively strong research ties with these countries and ranks among their top six research partners.³⁰² There may be opportunities to deliver high-quality research with Malaysia and Thailand in areas like agriculture, health and the environment, including natural hazard risk assessment and reduction. The growing economies and young populations of Indonesia and Vietnam position them well to become more significant players in global science in the future.

Research investment

The Australian Government's total support for science, research and innovation through the Federal Budget and other appropriations was \$8.97 billion for 2012–13.³⁰³ This support includes the Budget expenditure on universities and other government research agencies, research grants, research training and industry R&D tax incentives.³⁰⁴ The Government provides 30% of Australia's gross expenditure on R&D (GERD) and a significant proportion of business sector investment is facilitated by Government programs such as the R&D tax credit.

Table 4.1 shows a number of indicators of public expenditure on research and development as a proportion of Gross Domestic Product (GDP). These ratios are useful for country comparisons. Australia's GERD as a proportion of GDP increased from 1.58% in 1996–97 to 2.20% in 2010–11 (peaking at 2.26% in 2008–09), bringing it closer to the OECD average (2.36% in 2008–09). With regard to GERD as a percentage of GDP in 2010–11, Australia was in 11th place among OECD countries (Table 4.1). Australia's GERD in current dollar terms shows that spending on R&D increased substantially from \$8.8 billion in 1996–97 to \$30.8 billion in 2010–11.

Australia's expenditure on higher education R&D (HERD) was \$8.2 billion in 2010–11. Table 4.1 shows that the HERD/GDP ratio rose from 0.55% in 2008–09 to 0.59% in 2010–11. In 2010 Australia ranked 9th in the OECD in this indicator, an improvement from 11th in 2008.³⁰⁵ Government expenditure on R&D (GOVERD) as a percentage of the GDP remained at 0.27% in 2010–11 and Australia ranked 12th among the OECD in this measure. In most of the other indicators of public investment in R&D (Table 4.1), Australia ranks in the upper mid-range of the OECD. Refer to Chapter 2 for a discussion about business expenditure on research and development (BERD).

299 *Ibid.*

300 *Ibid.* Over the past decade, Singapore has jumped from a world ranking of eleven to two according to the Innovation Indicator 2011, BDI / Deutsche Telekom Stiftung, p10; on measures of expenditure on research per unit of GDP and scientific publications per capita, Singapore outperforms Australia.

301 Thomson Reuters (2011) Data, DIISRTE analysis.

302 *Ibid.*

303 Website reference

304 Australian Government (2013), The Australian Government's 2012–13 Science, Research and Innovation Budget Tables, DIICSRTE, Canberra.

305 Australian Government (2012) *Australian Innovation System Report—2012*, DIISRTE, Canberra, p.18.

Table 4.1 Australia's investment in research

Indicators	Australian trend data ⁽ⁱ⁾										OECD comparison				
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	Australia's score ⁽ⁱⁱ⁾	OECD average ⁽ⁱⁱⁱ⁾	OECD top 5 average ^(iv)	Gap from the top 5 OECD performers ^(v) (%)	Ranking against OECD countries ^(vi)
GERD as a % of GDP ¹	1.50	1.47	-	2.01	-	2.26	-	2.20	-	-	2.20	2.37	3.72	41.0	11th
GERD (\$b) ²	7.47	10.42	-	21.78	-	27.74	-	30.83	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
BERD as a % of GDP ¹	0.82	0.70	1.05	1.17	1.28	1.38	1.30	1.27	-	-	1.27	1.58	2.75	53.8	13th
BERD (\$b) ³	4.36	4.98	10.43	12.64	15.05	17.29	16.76	17.88	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
HERD as a % of GDP ¹	0.38	0.39	-	0.50	-	0.55	-	0.58	-	-	0.58	0.44	0.82	28.9	9th
HERD (\$b) ⁴	1.83	2.79	-	5.43	-	6.84	-	8.20	-	-	n.a.	n.a.	n.a.	n.a.	n.a.
GOVERD as a % of GDP ¹	0.40	0.33	-	0.29	-	0.27	-	0.27	-	-	0.27	0.29	0.40	31.2	12th
GOVERD (\$b) ⁵	1.98	2.36	-	3.10	-	3.42	-	-	3.53	-	n.a.	n.a.	n.a.	n.a.	n.a.
Proportion of private non-profit R&D as a % of GDP ¹	0.031	0.041	-	0.056	-	0.059	-	-	0.063	-	n.a.	n.a.	n.a.	n.a.	n.a.
Private Non-profit R&D (\$m) ⁵	153	289	-	609	-	744	-	-	925	-	n.a.	n.a.	n.a.	n.a.	n.a.
GBAORD as a % of GDP ^{1, (b)}	0.57	0.53	0.52	0.51	0.46	0.45	0.51	0.49	0.48	0.45	0.49	0.72	1.06	53.5	27th
GERD per capita (current PPP\$) ¹	318	411	-	741	-	881	-	918	-	-	918	722	1,311	30.0	12th
Government-financed GERD as a % of GDP ¹	0.71	0.67	-	0.76	-	0.78	-	-	-	-	0.78	0.59	0.91	14.4	7th
HERD financed abroad (%) ⁴	1.01	2.17	-	2.89	-	2.03	-	2.18	-	-	2.18	-	-	-	-
Proportion of HERD financed by business (%) ¹	4.66	5.32	-	6.76	-	5.85	-	4.89	-	-	4.89	5.62	13.41	63.5	12th
Proportion of GOVERD financed by business (%) ^{1, 5}	11.58	12.31	-	11.53	-	9.93	-	-	7.13	-	9.93	6.83	13.47	26.3	7th

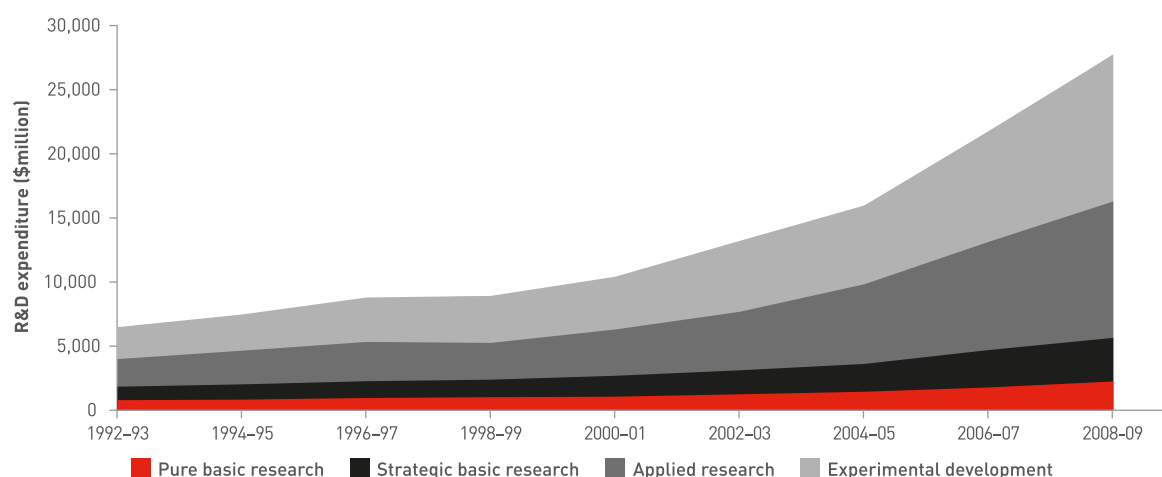
Sources: (i) OECD, Main Science and Technology Indicators, 2013/1. (ii) ABS [2010] *Research and Experimental Development, All Sector Summary, Australia, 2008-09*, cat. no. 8112.0, [3]. ABS [2012] *Research and Experimental Development, Businesses, Australia, 2010-11*, cat. no. 8104.0. (iii) ABS [2012] *Research and Experimental Development, Higher Education Organisations, Australia, 2010*, cat. no. 8111.0. (iv) ABS [2013] *Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2011-12*, cat. no. 8109.0.

Indicator notes: GERD = Gross Expenditure on R&D; BERD = Business Expenditure on R&D; HERD = Higher Education Expenditure on R&D; GOVERD = Government Expenditure on R&D; GBAORD = Government Budget Appropriations or Outlays for R&D. (a) With the exception of the business R&D (BERD) indicators, 1994 data has been used in the absence of 1995 data. (b) For comparison with the OECD, 2011 data has been used. (c) OECD comparison is for the latest year that Australian trend data is shown, unless otherwise noted for that indicator.

Table notes: (i) Data is presented in calendar year format. Where the data is in financial years, it is expressed in terms of the year where the financial year begins e.g. 2010-11 is shown as 2010. (ii) The 'Australia's score' field presents the Australian values used in the OECD comparisons. (iii) This is the arithmetic (simple) average of the OECD country scores. (iv) This is the arithmetic (simple) average of the top five OECD countries in a ranked list. (v) This represents Australia's distance from the frontier as defined by the average of the top five ranked OECD countries. It is calculated as $100 \times (\text{Top five average} - \text{Australia's score}) / \text{Top 5 average}$. Where the solution is a negative value or zero, "no gap" is shown in the cell. (vi) OECD rankings are performed on those OECD countries for which data is available. Individual data availability may vary between indicators. "-" = data not available.

Chart 4.1 compares GERD by type of activity, from 1992–93 to 2008–09. The four types of activities included in the chart are ‘pure basic research’, ‘strategic basic research’, ‘applied research’ and ‘experimental development’.³⁰⁶ Australian expenditure on all of these activities increased during this period. In particular, ‘applied research’ and ‘experimental development’ grew from \$2.15 billion to \$10.6 billion and from \$2.49 billion to \$11.46 billion respectively.

Chart 4.1 Gross Expenditure on R&D by type of research, 1992–93 to 2008–09



Source: Australian Bureau of Statistics (various years) Research and Development, All Sector Summary, Australia 1992–93 to 2008–09, cat. no. 8112.0. More recent data is unavailable as the ABS has ceased collecting this information.

Over the past decade a number of reviews and studies have suggested that Australia must enhance interaction between the research and industry sectors in order to drive up innovation outputs and outcomes in industry.³⁰⁷ Increasing funding for, or re-directing funding to, applied research is often suggested as a way to orient the research sector more towards the practical, problem-solving aspects of economic development and make research more immediately relevant and applicable to productivity growth in the industry. This transition has been taking place with total research sector expenditure on applied research and experimental development having grown five-fold since the early 1990s, faster than basic research.³⁰⁸

In fact the proportion of higher education expenditure on basic and strategic research has steadily declined in the past two decades, while the proportion directed to applied and experimental research has steadily increased.³⁰⁹ ABS data indicates that while actual expenditure on basic research increased over the 15 years to 2008–09, the proportion of Australia’s research effort directed to basic research decreased from almost 30% to around 20%, with around 80% allocated to applied research.³¹⁰ The bulk of the investment in applied research comes from the private sector, with the Australian Government and the higher education sectors supporting and carrying out most basic research. In 2008–09 the Government contributed 75% of the total expenditure on basic and strategic research conducted in Australia.³¹¹ In the same period, the higher education sector accounted for almost 60% of basic research,³¹² although the proportion of higher education expenditure directed to basic research has declined markedly over the past 20 years.^{313 314}

306 The ABS definitions that apply to the Chart 5.1 are: **Pure basic research:** Experimental and theoretical work undertaken to acquire new knowledge without looking for long term benefits other than the advancement of knowledge; **Strategic basic research:** Experimental and theoretical work undertaken to acquire new knowledge directed into specified broad areas in the expectation of practical discoveries. It provides the broad base of knowledge necessary for the solution of recognised practical problems. **Applied research:** Original work undertaken primarily to acquire new knowledge with a specific application in view. It is undertaken either to determine possible uses for the findings of basic research or to determine new ways of achieving some specific and predetermined objectives. **Experimental development:** Systematic work, using existing knowledge gained from research or practical experience, which is directed to producing new materials, products, devices, policies, behaviours or outlooks; to installing new processes, systems and services; or to improving substantially those already produced or installed.

307 Australian Government (2009) *Powering Ideas: An Innovation Agenda for the 21st Century*, DIISR, Canberra; Australian Government (2012) National Research Investment Plan, DIISRTE, Canberra; Australian Government (2013) A Plan for Australian Jobs: Industry and Innovation Statement, DIISRTE, Canberra.

308 Australian Government (2012) *Australian Innovation System Report 2012*, DIISRTE, Canberra, p22.

309 Australian Government (2012) *Health of Australian Science*, the Office of the Chief Scientist, Canberra.

310 ABS (2010) Research and Experimental Development, All Sector Summary, Australia (various issues), cat. no. 8112.0.

311 Australian Government (2012) *Health of Australian Science*, the Office of the Chief Scientist, Canberra.

312 ABS (2010) Research and Experimental Development, All Sector Summary, Australia, 2008–09, cat. no. 8112.0.

313 Australian Government (2012) National Research Investment Plan, DIISRTE, Canberra.

314 GERD data by socio economic objective (SEO) and type of research (basic, applied and experimental development) that shows changes in the orientation of research is not available after 2008–09 as the ABS has stopped collecting this data.

Over time this trend may become problematic. The report *The Health of Australian Science* has highlighted the potentially significant contributions of basic research to innovation, particularly radical innovation. It notes the strategic role of basic research in society through its contribution to our stock of intellectual capital, which can be used to develop, improve and even transform society.³¹⁵ Intellectual capital is a major resource that can be drawn on to develop new technologies and innovative processes, which can be traded as intellectual property or used to set up spin-off businesses. Without a world-class capacity for both basic and applied research leading to innovative solutions, Australia will be locked into a path of lower productivity and lower living standards.

Without basic research, applied research will continue to drive greater efficiencies, but the chance of more radical, new-to-the-world innovations will be limited. Australia has shown the capacity to produce radical innovations in wireless technology and medical devices—innovations that had their genesis in basic research. It is difficult to determine what the right balance between these forms of R&D as it is time- and context-specific. Even when the majority of Australian firms are adopters and modifiers of innovations generated elsewhere, Australia needs an innovation system capable of undertaking radical and new-to-the-world innovation—and basic research underpins this capacity.

Research income and research commercialisation

University block grants are an important investment in national research capability. The block grants provide universities with the ability to respond strategically to emerging national challenges or take advantage of an emerging business opportunity. They also allow universities to support new fields of research and early career researchers.

Universities' research income comes from four broad categories: competitive grants, other public research funding, industry and other funding (including contracts, consultancies and international sources), and funding associated with the Cooperative Research Centres (CRC) program. Table 4.2 shows that universities' research income from the first three categories has increased steadily since 1998 and, especially, since the broad framework for the block grant schemes were introduced in 2001. Income associated with the CRC program has declined since 2008.

A select number of public research commercialisation outcomes are reported here (Table 4.2). A complete overview of research commercialisation data can be found in the National Survey of Research Commercialisation report.³¹⁶ Annual invention disclosures, a formal record of ideas with commercial potential, show strong growth in Australia since 2000 relative to investment in R&D. These rates of invention disclosure are now on par with Europe and trending towards North American levels.³¹⁷ Although research commercialisation outcomes from Australian public research institutions generally show positive growth in absolute terms, relative to increasing levels of investment in R&D, many indicators such as patenting, licensing and start-up activity are in decline. These trends are generally consistent with trends in Europe and North America.

315 Australian Government (2012) *Health of Australian Science*, the Office of the Chief Scientist, Canberra.

316 Australian Government (2012) *The National Survey of Research Commercialisation 2010-2011*, DIISRTE, Canberra

317 *Ibid.*

Table 4.2 Funding of research and research commercialisation outcomes

Indicators	Australian trend data										
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	
Number of formal agreements on academic/research collaboration between Australian universities and overseas institutions ^{1,(a)}	-	3,089	3054	-	3,421	-	3,493	-	-	-	5,086
Adjusted gross income from Licenses, Options and Assignments by publicly funded research agencies and universities (\$million) ^{2,(b)}	-	136	68	117	238	94	315	146	91	-	
Gross income from contracted research and consultancies by publicly funded research agencies and universities (\$billion) ^{2,(b)}	-	-	1.31	1.29	1.40	1.26	1.24	1.48	1.36	-	
Number of start-up companies in which publicly funded research agencies and universities have an equity holding ²	-	66	154	172	178	173	176	165	166	-	
Number of Australian patent and plant breeder rights filed by publicly funded research agencies and universities ²	-	533	462	495	470	567	645	673	669	-	
Number of LOAs yielding income from publicly funded research agencies and universities ²	-	472	537	577	587	523	580	742	721	-	
Universities' income from Cooperative Research Centre Research (CRC) ³	-	81	130	131	126	124	123	119	108	-	
University income from industry ³	-	331	492	627	672	773	666	797	832	-	

Sources: [1] Universities Australia, *International Links of Australian Universities* 2009 and 2012. [2] DIISRTE (2012), *National Survey of Research Commercialisation 2010-11*. [3] Higher Education Research Data Collection (HERDC), 2011.

Notes: (a) For 2000 and 2005, the 2001 and 2003 figures were used respectively. (b) All figures are in constant 2011 prices.

Australia's research workforce

The availability of a highly skilled workforce is central to knowledge-based economies and an enabling element of a national innovation system. Research skills are particularly important, as the pace of social and technological change increases demand for creative individuals who can push the boundaries of knowledge and assess and adapt new technologies and ideas as they emerge.³¹⁸

The research sector (i.e. universities, CSIRO and other research institutions) plays a fundamental part in educating the research workforce and thus enhancing the ability of businesses to conduct R&D. People who have completed a Higher Degree by Research (HDR) and, particularly human resources with specialised technical skills in science and technology (HRST), play a key role in maintaining R&D activities and adopting new technologies. In most OECD countries, HRST represented more than a quarter of total employment in 2010.³¹⁹

Total full-time equivalent human resources devoted to R&D in Australia in 2008–09 (the latest period for which complete data is available) amounted to 136,696 persons. Over two thirds (67%) were researchers, with the remainder being technicians or other dedicated support staff. The number of human resources devoted to R&D in Australia has risen over time, increasing by 49% over the last decade alone.³²⁰

Table 4.3 presents two indicators where Australia outperforms the OECD average in terms of researchers as a percentage of total labour force and R&D personnel as a percentage of total employment. Furthermore, Australia has a percentage of researchers in its workforce comparable to North American and European nations, but lower than Scandinavian countries.³²¹

An OECD cross-country comparison of the sectoral distribution of the research workforce (Chart 4.2) shows that Australia has a small proportion of its research workforce employed in the business sector compared with many other advanced countries.³²² Such a distinct result should place more emphasis on a high level of industry-research collaboration in the short to medium term as a first step towards being a global leader on innovation. However, Australia's industry-research collaboration on innovation is one of the lowest in the OECD (See Chapter 2). The UK has a similar distribution of researchers in business but also has the third highest level of SME-research collaboration in the OECD. Australia by comparison is last in the OECD on this indicator despite relatively high standing in public research quality and quantity as well as trending to more applied research and experimental development in public research organisations. This result may reflect the distinction between Australia and other advanced OECD countries on the level of world-first innovation. Australia has low rates of world-first innovation compared with other leading OECD economies.³²³ There is a strong relationship between world first innovation, collaboration and the use of research and engineering skills. These data taken together suggest low demand for employing researchers and collaboration with researchers in Australian industry despite decades of government policies at state and federal levels to encourage more industry-research collaboration. More systemic policies may be needed to allow this knowledge market to function effectively by:

- Encouraging a broad cultural shift in Australian businesses to one of enquiry, linkage and collaboration; and
- Providing stronger systemic incentives for the research sector to engage with industry.

318 Australian Government (2011) *Research skills for an innovative future: A research workforce strategy to cover the decade to 2020 and beyond*, DIISR, Canberra.

319 OECD (2011) *OECD Science and Industry Scoreboard 2011: innovation and Growth in Knowledge Economies*, OECD Publishing.

320 Australian Government (2011) *Research skills for an innovative future: A research workforce strategy to cover the decade to 2020 and beyond*, DIISR, Canberra.

321 Pettigrew AG (2012) Australia's position in the world of science, technology & innovation, *Occasional Paper Series 2*, Australia's Chief Scientist, Canberra, p.1.

322 OECD (2011) *OECD Science and Industry Scoreboard 2011: innovation and Growth in Knowledge Economies*, OECD Publishing.

323 Australian Government (2011) *Australian Innovation System Report 2011*, DIISRTE, Canberra, p23.

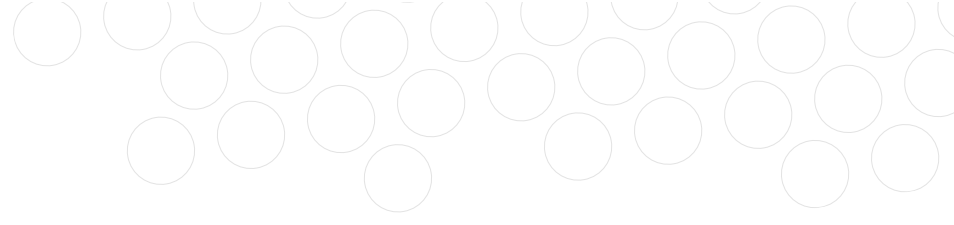
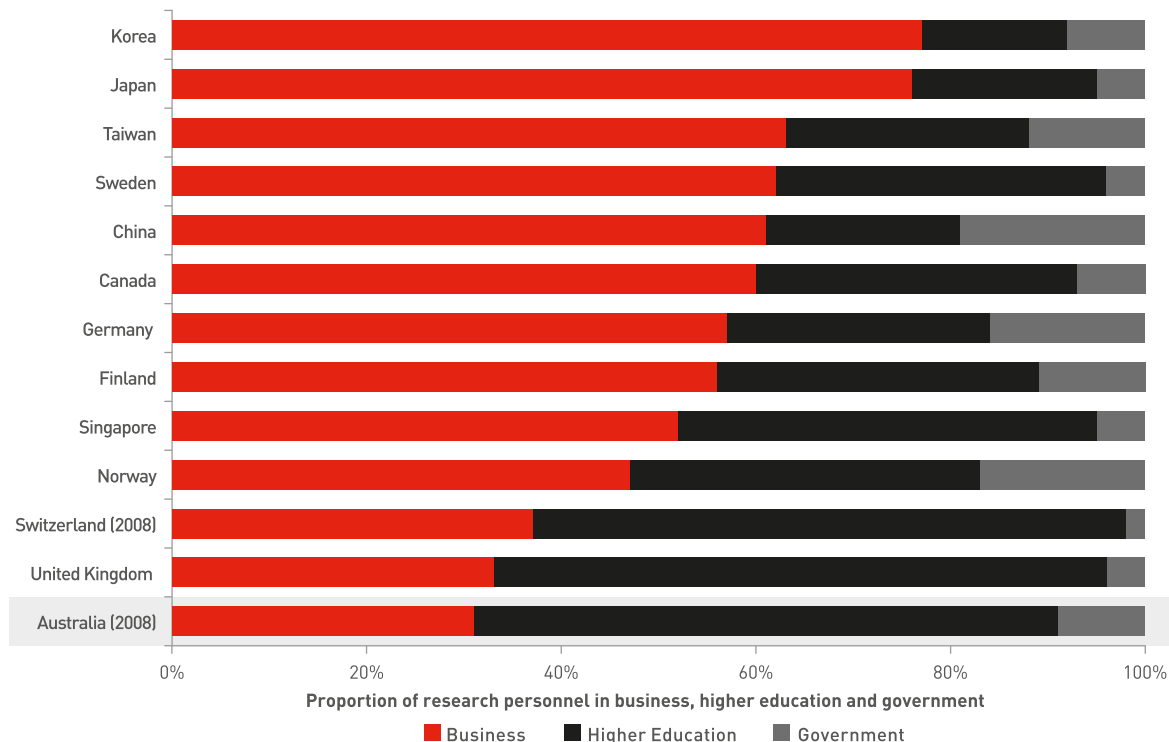


Chart 4.2 Proportion of research personnel in business, higher education and government, by selected countries, 2010



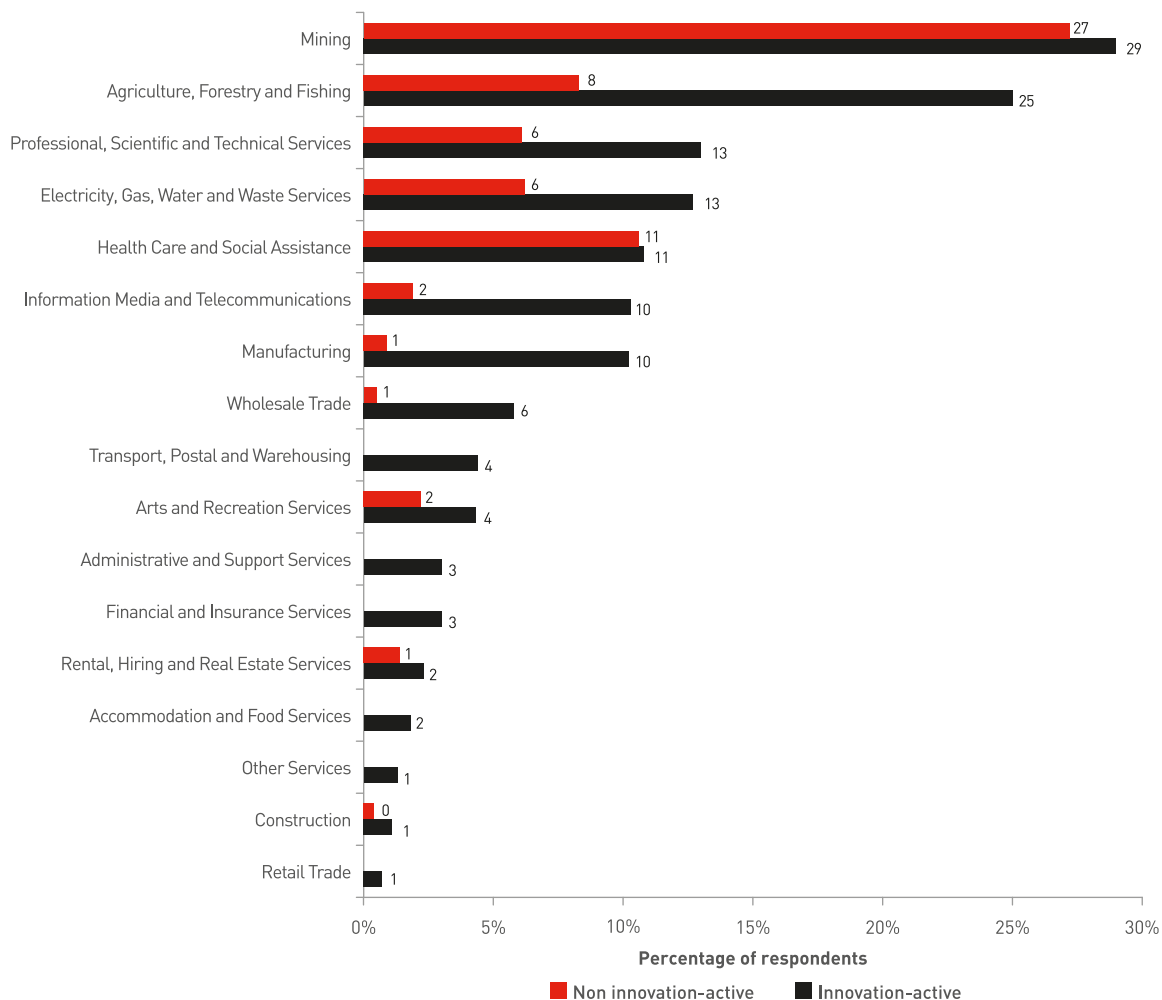
Source: OECD (2013) Main Science and Technology Indicators, January 2013.

Note: Data for 2010 or nearest available year

The Australian higher education sector was responsible for employing around 60% of the nation's research personnel in 2008, followed by the business sector at 31% and government sector at 9%. The lower proportion of researchers in the business sector is likely to reflect the structure of Australian industrial sector, which is characterised by a small manufacturing sector specialising in low and medium technological activities, and the fact that business decisions regarding R&D have focused more on the implementation of incremental innovations. It is encouraging that the proportion of researchers in the business sector has increased from 25% in 2000 to 31% in 2008. This increase has occurred predominantly in large firms which are much more likely to introduce world-first innovations.

These issues are highly sector-specific. Industry research collaboration varied considerably between sectors and business sizes (See Chapter 2). Chart 4.3 ranks Australian industry sectors by the level of usage of science and research skills. Innovation-active firms in resource-based sectors are most likely to use science and research skills with more than a quarter of these businesses identifying these skills. In the case of healthcare and mining, the use of science and research is a key skill for undertaking core business activities regardless of innovation status. However, in sectors such as manufacturing and information media and telecommunication, which have knowledge bases that are of highly technical nature, the use of science and research skills is limited: about 90% of the innovation-active firms in these sectors do not use science and research skills for their core business activities.

Chart 4.3 Science and research skills used in undertaking core business activities by industry sector and innovation status



Source: ABS (2012) Selected Characteristics of Australian Business, 2010–11, cat. no. 8167.0

It is important to note that agriculture and mining are two sectors where Australian world leadership, in terms of both innovation and export performance, is well recognised. In agriculture, Australia has produced new-to-the-world innovations such as Nogall pest control, the world’s first commercial release of a living, genetically engineered organism.³²⁴ The Qemscan mineral analyses system is also an example of new-to-the-world innovation in mining developed in Australia.³²⁵ Both these sectoral innovation systems demonstrate the strong link between world first-innovation and engagement of science and research skills in industry.

Human resources devoted to research and development have grown significantly in Australia over the last decade.³²⁶ Projected to increase at 3.2% per annum over the period to 2020, this growth, if sustained, will be much faster than growth in total employment, which is projected to be 1.5% per annum.³²⁷ Demand by business, academia and government for people with higher degree research (HDR) qualifications is projected to outstrip supply by 2020.³²⁸

A Higher Degree by Research remains the most important training pathway to research and research-related roles in Australia. It reflects a dedicated investment over several years in developing deep subject expertise and a rigorous methodological grounding for conducting research at the highest

324 <http://www.powerhousemuseum.com>. http://www.powerhousemuseum.com/australia_innovates/media/a_century_of_innovation.pdf. <http://www.ausinnovation.org/articles/australias-top-100-innovations.html>.

325 CSIRO (2004) *Minister launches new QEMSCAN Company*, Process Magazine, CSIRO Minerals, p.1.

326 Australian Government (2009) Internal analysis of DEEWR Selected Higher Education Statistics, DIISR, Canberra.

327 Access Economics (2010), *Australia’s future research workforce: supply, demand and influence factors*, a report for DIISR, Canberra.

328 *Ibid.* Note: these projections need to be considered with the necessary caution as they are based in a number of assumptions in three main scenarios: base, low case and high case. A summary of these assumptions are in the Access Economics report, p.36.

level. HDR completion rates are therefore an indicator of research workforce development. Australia's recent production of domestic higher degree qualified graduates rose by less than 0.7% between 2006 and 2012. This suggests that migration and retention of international students in Australia may be important to meet the demand for research-qualified staff in the medium term.

Table 4.3 shows that the number of students completing HDR in Australia has increased sharply since 2005. In 2010, for example, the number of students completing HDR in Australia increased by 4.3% to 7,401 and, in 2012, this number rose again to 8,230.³²⁹ This growth is predominantly due to an increase in international students.³³⁰ While in 2009 around 24% of students completing their degree by research were from overseas, more recent data indicates that overseas students made up 33% of all HDR completions in 2012.³³¹ There was a sharp rise in the number of international HDR student completions in Australia in the decade 2001–2011. This number more than doubled from 911 in 2001 to 2,295 in 2011.³³² In 2012 the number of international HDR completions reached 2,629.³³³ A large proportion of international HDR students came from Asian countries. In 2011, students from China accounted for 15.6% of total international HDR students, followed by students from Malaysia at 7.3%, students from Indonesia at 5.6%, students from Vietnam at 5.0%, and students from Singapore at 3.6%.³³⁴ These figures highlight Australia's growing research integration with Asia.

In 2009, a total of 7,092 HDR students completed their awards in Australian universities.³³⁵ In 2012, the number of students completing a higher degree by research in Australia was 8,230.³³⁶ In 2012, the largest numbers of HDR students competed their degrees in Natural and Physical Sciences (1,822), followed by Society and Culture (1,688).³³⁷ Table 4.3 also shows that Australia ranks relatively well (9th place) in the OECD in terms of HDR graduation rate.

Australian universities provide the majority of formal research training and confer all HDR qualifications. However, research training can also take place in a wide variety of other settings, including public research agencies.³³⁸ Almost all research training is supported by public funding, although support from industry bodies and employers, community partners and public sector research agencies has increased to just under \$1.79 billion in 2011 (the latest data available).³³⁹

Employers in both the private and public sectors have identified a need for research graduates to have improved 'soft' skills such as communication, teamwork, project management and commercialisation.³⁴⁰ An Australian Association of Graduate Employers' survey in late 2011 confirmed that soft skills rate far more highly with employers than academic grades.³⁴¹ This may be less so for roles that require advanced research or technical skills, however core competencies such as teamwork and interpersonal skills were "very important" for 90% of employers who responded to the survey. The next most valued attributes were verbal communication and problem-solving skills.³⁴²

329 Australian Government (2011) Analysis of Higher Education Statistics – unpublished data, DIICCSR, Canberra.

330 Australian Government (2011) Defining Quality for Research Training in Australia: a Consultation Paper, DIISR, Canberra.

331 Australian Government (2012) Award course completions 2012: selected higher education statistics tables, DIISRTE, Canberra.

332 DIICCRTE Analysis of Higher Education Statistics, unpublished data.

333 Australian Government (2012) Award course completions 2012: selected higher education statistics tables, DIISRTE, Canberra.

334 DIICCRTE Analysis of Higher Education Statistics, unpublished data.

335 *Ibid.*

336 Australian Government (2012) Award course completions 2012: selected higher education statistics tables, DIISRTE, Canberra.

337 *Ibid.*

338 Australian Government (2011) Defining Quality for Research Training in Australia: a Consultation Paper, DIISR, Canberra.

339 Australian Government (2013) Research, higher education, skills and international education; Highlights as at May 2013, DIICCSRTE, Canberra.

340 Australian Government (2012) National Research Investment Plan, DIISRTE, Canberra.

341 Australian Association of Graduate Employers (AAGE) (2011) The AAGE Employer Survey 2011, AAGE, Camberwell Victoria.

342 Mather J (2011) Employers rate soft skills higher than grades, *The Australian Financial Review*, 7 November 2011, p.28.

Table 4.3 Indicators of Australia's research workforce

Indicators	Australian trend data										OECD comparison ^(a)				
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	Australia's score	OECD average	OECD top 5 average	Gap from the top 5 OECD performers	Ranking against OECD countries
Number of students completing higher degree by research in Australia ¹	-	5,431	6,809	7,094	7,135	7,174	7,091	7,401	7,895	8,230	-	-	-	-	-
Domestic students ¹	-	4,554	5,504	5,562	5,501	5,553	5,381	5,460	5,603	5,601	-	-	-	-	-
International students ¹	-	877	1,305	1,532	1,634	1,621	1,710	1,941	2,292	2,629	-	-	-	-	-
PhD graduation rate (%) ²	-	-	1.70	1.79	1.89	1.91	1.89	1.85	1.89	-	1.89	1.59	2.74	31	11th
Proportion of international students enrolled in advanced research programs ²	-	-	17.80	19.10	20.80	23.30	26.30	28.70	30.71	-	30.71	19.65	39.35	22	5th
Researchers as a % of total labour force ³	0.64	0.68	0.79	0.81	-	0.81	-	-	-	-	0.81	0.70	1.20	32	1st
R&D personnel as a % of total employment ³	1.07	1.06	1.18	1.22	-	1.26	-	-	-	-	1.26	1.16	1.84	31	14th
Share of professionals and technicians in total employment (%) ⁴	-	-	-	37.6	-	35.8	-	36.1	-	-	36.1	31.8	42.4	15	9th
Local availability of specialised research and training services ^{5, (a)}	-	-	-	5.31	5.20	5.27	5.28	5.26	5.39	5.32	5.32	5.14	6.13	13	14th

Sources: [1] Higher Education Information management System (HEIMS) student data collection. [2] OECD (various), Education at a Glance. [3] OECD, *Main Science and Technology Indicators database, 2013/1*. [4] OECD (various), *Science, Technology and Industry Scoreboard*. [5] WEF World Economic Forum (various), *The Global Competitiveness Report*.

Indicator notes: (a) For this indicator, survey respondents were asked to answer the question "in your country, to what extent are high-quality, specialized training services available? [1 = not available; 7 = widely available]"

Table notes: (i) Data is presented in calendar year format. Where the data is in financial years, it is expressed in terms of the year where the financial year begins e.g. 2010-11 is shown as 2010. (ii) The 'Australia's score' field presents the Australian values used in the OECD comparisons. (iii) This is the arithmetic (simple) average of the OECD country scores. (iv) This is the arithmetic (simple) average of the top five OECD countries in a ranked list. (v) This represents Australia's distance from the frontier as defined by the average of the top five ranked OECD countries. It is calculated as 100*(Top five average - Australia's score)/Top 5 average. Where the solution is a negative value or zero, 'no gap' is shown in the cell. (vi) OECD rankings are performed on those OECD countries for which data is available. Individual data availability may vary between indicators. "-" = data not available.

Research performance

Table 4.4 shows eleven indicators of the progress of Australia's research output in terms of publications and citations, compared with other OECD countries. These indicators show a general trend of improvement. For example, Australia's share of world publications has improved 32% over this period from 2.61% in 2006 to 3.44% in 2012. Australian research has increased the number of fields with higher than world-average citation rates in the period 2008–2012. Only one field out of 22 was below the world average citation rate for that field. In terms of total citations per publication and the relative impact of publications Australia also has shown improvement, but a gap still exists with the top five OECD performers. In indicators of research excellence, such as the share of the top 1% of highly cited publications, Australia has improved over time and is now ranked in 8th position in natural sciences and engineering and in 6th position in social sciences compared to other OECD countries.

Table 4.4 also includes indicators of international collaboration and quality of publications. This is the share of the world's top 1% of highly cited publications attributed to collaboration for the natural sciences and engineering and the social sciences and humanities. The data suggests that Australia's growing share of the world's top 1% of research is increasingly attributed to international collaboration. Research publications involving international collaboration make up the majority of Australia's world's best publications (top 1%) and this proportion grew from 2.27% in 2006 to 3.52% in 2012 (Table 4.4). As Table 4.4 shows, this trend is continuous, but also broad-based, encompassing the natural sciences and engineering, as well as the social sciences and humanities.³⁴³

University research quality assessment

The Excellence in Research for Australia (ERA) process assesses the quality of Australian research publications on the basis of the principle of expert review, informed by a suite of indicators on research quality, volume, application and recognition.³⁴⁴ The ERA process aims to identify and promote excellence across the full spectrum of research activity, including both discovery and applied research, within Australian universities.³⁴⁵

Two rounds of ERA evaluations have been carried out to date. The first, held in 2010, used a reference period of 1 January 2003 to 31 December 2008 for research outputs and 1 January 2006 to 31 December 2008 for most other measures. The second was held in 2012 and used a reference period of 1 January 2005 to 31 December 2010 for research outputs and 1 January 2008 to 31 December 2010 for most other measures.³⁴⁶ *The Excellence in Research for Australia 2012 National Report* confirms that researchers at Australian universities can compete with the world's best in a wide range of disciplines.³⁴⁷

The Unit of Evaluation (UoE) for ERA is a research discipline within an institution as defined by Australian and New Zealand Standard Research Classification codes, usually referred to as 'field of research' or FoR codes. A total of 2,323 UoEs were assessed in the ERA 2012 process. Each UoE was assessed against the 5 point ERA rating scale, which is broadly consistent with the approach taken in research evaluation processes in other countries to allow for international comparison. According to this scale:

- 5s signify that the UoE profile is characterised by evidence of outstanding performance well above world standard.
- 4s signify that the UoE profile is characterised by evidence of performance above world standard.
- 3s signify that the UoE profile is characterised by evidence of performance at world standard.
- 2s signify that the UoE profile is characterised by evidence of performance below world standard.
- 1s signify that the UoE profile is characterised by evidence of performance well below world standard.³⁴⁸

Note that in this scale, 'World Standard' refers to a quality standard. It does not refer to the nature or geographical scope of particular subjects. Each point on the rating scale represents a quality 'band' and Each UoE is assessed against the absolute standards of the rating scale, not against other UoEs.

³⁴³ Thomson Reuters (2013) *InCites™*, special request by DIICCSRTE March 2013.

³⁴⁴ Australian Research Council (2012) *Excellence in Research for Australia 2012—National Report*, Australian Research Council, Canberra, p.5.

³⁴⁵ Australian Research Council (2012) *Excellence in Research for Australia 2012—National Report*, Australian Research Council, Canberra, p.3.

³⁴⁶ The overlap between the reference periods, especially in relation to research outputs, and the differences in the 2012 process (largely resulting from feedback on the 2010 process) mean that caution must be taken in comparing the two sets of results, or in drawing any inferences about how individual universities or the research sector as a whole may be changing research strategies or priorities.

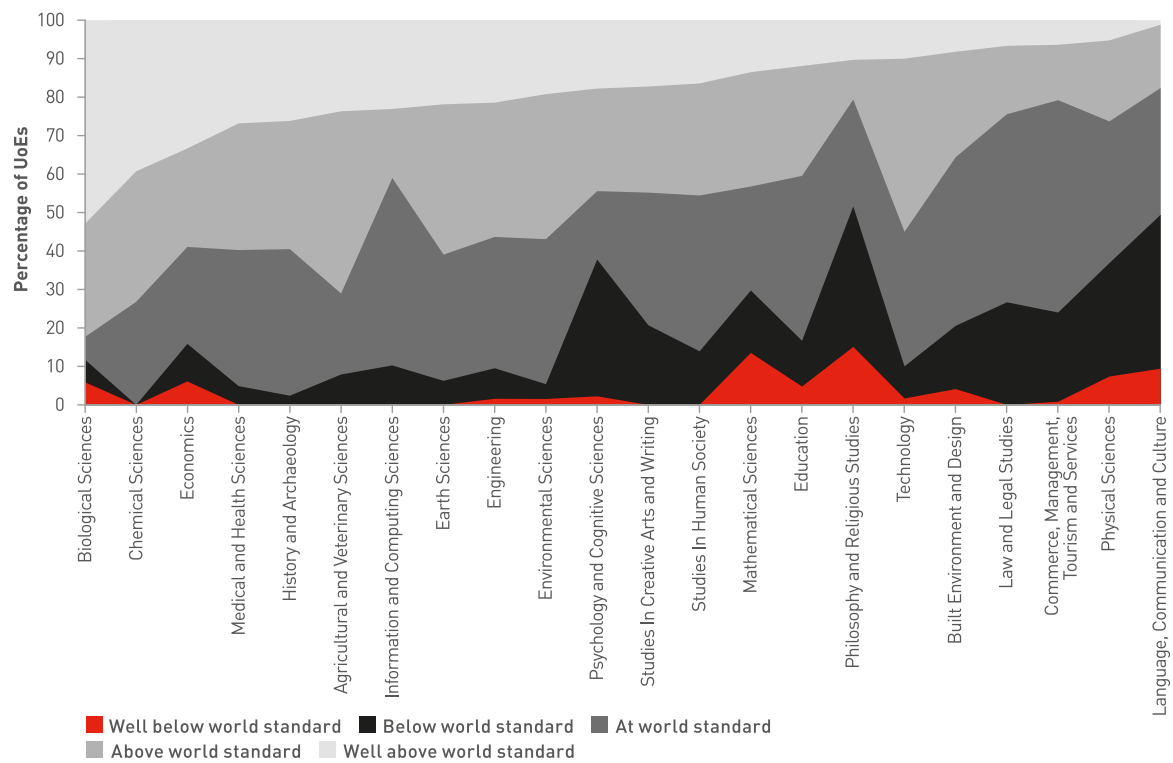
³⁴⁷ Australian Research Council (2012) *Excellence in Research for Australia 2012—National Report*, Australian Research Council, Canberra.

³⁴⁸ Australian Research Council (2012) *Excellence in Research for Australia 2012—National Report*, Australian Research Council, Canberra, p.7.

Chart 4.4 shows the proportions of UoEs by ERA ratings for 2012 for 22 two-digit FoRs. In addition to the FoR ratings, the ERA results also provide other information about the strengths and possible shortcomings of Australia's overall research capacity. Australia's science and engineering research disciplines have highly rated performance. The results of the 2012 assessment also confirm the well-established and widely-recognised strength of research in Medical and Health Sciences in Australia, with 95% of work in this area at or above world standard, a high level of research and research commercialisation income, and high levels of esteem for researchers in this field. Medical and Health Sciences is also the single largest area of research activity, involving more than 9,000 full-time equivalent staff in almost 250 UoEs and producing almost 92,000 research outputs and 208 patents.

Chemical Sciences, Earth Sciences and Engineering have high levels of research output at or above world standards, with the percentage of UoEs at 100%, 95% and 90% respectively).³⁴⁹ The high level of UoEs in Earth Sciences assessed at or above the world standards in 2012 suggests that the mining sector can rely on the latest and best research outcomes through our universities. Other fields of research with a high percentage of UoEs at or above world standards in 2012 ERA assessment were History and Archaeology (97%), Environmental Sciences (95%), Agricultural and Veterinary Sciences (92%), Technology (90%), Information and Computer Sciences (90%), Biological Sciences (88%), Studies in Human Society (86%), Education (84%) and Economics (84%).

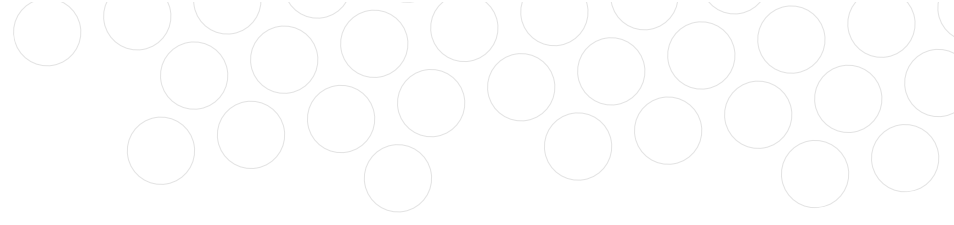
Chart 4.4 Research performance of Australian universities: Proportion of Units of Evaluation by ERA rating, 2012



Source: ERA (2012) *The Excellence in Research for Australia 2012—National Report*

Notes: 'World Standard' refers to a quality standard. It does not refer to the nature or geographical scope of particular subjects. Each point within the rating scale represents a quality 'band'. Each UoE is assessed against the absolute standards of the rating scale, not against other UoEs.

349 Australian Research Council (2012) *Excellence in Research for Australia 2012—National Report*, Australian Research Council, Canberra, p.5.



All 22 two-digit Fields of Research show a general improvement between the two ERA assessments undertaken in 2010 and 2012.³⁵⁰ For example, the proportion of UoEs assessed as above world standard increased by 35% in Economics, 33% in Biological and Chemical Sciences, and 29% in Education and Studies in Human Societies.

There are, however, some areas of concern. In such fields as Language, Communication and Culture, and Philosophy and Religious Studies, around 50% of the research output were found to be below world standards in the 2012 ERA assessment. Despite its high level of at or above world standards rating, Technology research also seems to be an area of possible concern. In the 2012 assessment only 627 full-time-equivalent staff were involved in research in these fields, the second lowest (after Philosophy and Religious Studies) of any high-level field of research. The interdisciplinary nature of research means that there are many other science and engineering fields that spill over into Technology fields and vice-versa. More research is needed to determine whether there are also significant and similar capability gaps in industry. If so, some capacity building may be required to improve our capability for world first innovation.

³⁵⁰ It is important to note that there are differences in the assessment methodologies used in 2010 and 2012 therefore comparisons between these years need to be done with care.

Table 4.4 Quality measures of Australia's research publications

Indicators	Australian trend data ⁽ⁱ⁾										OECD comparison				
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	Australia's score ⁽ⁱⁱ⁾	OECD average ⁽ⁱⁱⁱ⁾	OECD top 5 average ^(iv)	Gap from the top 5 OECD performers ^(v) [%]	Ranking against OECD countries ^(vi)
Share of world publications (a)	2.46	2.77	2.89	2.92	2.97	3.03	3.10	3.20	3.29	3.39	3.39	2.84	11.09	69.4	9th
Number of fields with higher than world average citation rate by field ^(a)	10	13	16	17	17	17	18	19	20	21	-	-	-	-	-
Citations per publication ^(a)	3.08	3.90	4.94	5.08	5.29	5.57	5.75	6.00	6.22	6.36	6.36	6.21	8.60	26.1	18th
Share of world's top 1% highly cited publications, natural sciences and engineering (b)	-	-	-	3.76	3.99	4.42	4.87	5.14	5.43	5.49	5.49	4.37	20.35	73.0	8th
Share of world's top 1% highly cited publications, social sciences (b)	-	-	-	2.65	2.98	3.54	4.31	4.66	4.79	5.14	5.14	3.34	16.13	68.1	6th
Share of world's top 1% highly cited publications attributed to domestic collaboration, Natural Sciences and Engineering [%] ^(b)	-	-	-	1.31	1.46	1.72	1.94	2.16	2.47	2.49	2.49	2.21	9.89	74.8	8th
Share of world's top 1% highly cited publications attributed to domestic collaboration, Social Science and Humanities [%] ^(b)	-	-	-	0.45	0.63	0.87	0.95	1.13	1.33	1.41	1.41	1.13	5.90	76.1	6th
Share of world's top 1% highly cited publications attributed to international collaboration, All disciplines [%] ^(b)	-	-	-	2.27	2.39	2.65	3.05	3.31	3.49	3.52	3.52	2.59	9.28	62.1	8th
Share of world's top 1% highly cited publications attributed to international collaboration, Natural Sciences and Engineering [%] ^(b)	-	-	-	2.43	2.52	2.81	3.22	3.52	3.66	3.64	3.64	2.73	9.74	62.6	10th
Share of world's top 1% highly cited publications attributed to international collaboration, Social Science and Humanities [%] ^(b)	-	-	-	0.86	1.14	1.21	1.47	1.48	1.75	2.07	2.07	1.16	4.65	55.5	6th

Source: [1] InCitesTM, Thomson Reuters (2012).

Indicator notes: All indicators are based on the Thomson ISI Essential Science Indicators. (a) Years span four year ranges i.e. 2006=2002-2006. (b) Years span two year ranges i.e. 2006=2004-2006.

Table notes: (i) Data is presented in calendar year format. Where the data is in financial years, it is expressed in terms of the year where the financial year begins e.g. 2010-11 is shown as 2010. (ii) The Australia's score 'field' presents the Australian values used in the OECD comparisons. (iii) This is the arithmetic (simple) average of the OECD country scores. (iv) This is the arithmetic (simple) average of the top five ranked OECD countries. It is calculated as 100* (Top five average - Australia's score)/Top 5 average. Where the solution is a negative value or zero, "no gap" is shown in the cell. (v) OECD rankings are performed on those OECD countries for which data is available. Individual data availability may vary between indicators. "-" = data not available.

FEATURE ARTICLE: EXCELLENCE IN INNOVATION FOR AUSTRALIA (EIA) RESEARCH IMPACT ASSESSMENT TRIAL 2012



Dr Matthew Brown , Senior Policy Analyst (Research), Australian Technology Network of Universities

In 2012 the Australian Technology Network of Universities (ATN) and the Group of Eight Universities (Go8) conducted a proof of concept trial of a comprehensive research impact assessment process for the research produced by Australian universities. Across 12 universities 162 case studies, accompanied by fit-for-purpose performance indicators, were submitted in the broad impact areas of Defence, Economic Development, Society, and Environment. The case studies were evaluated by expert panels comprising some 70% membership by senior industry figures to provide a real-world rating of real-world impacts. The final report³⁵¹ of the EIA was released in November 2012.

As a headline figure the EIA showed that nearly 87% of assessments were at the level of considerable impact or higher.

To set the context for the EIA it is important to note the contribution of universities to the Australian innovation system. Australia has one of the highest percentages of its researchers in universities amongst developed economies– nearly 60%.³⁵² Australian universities also direct significant investment into research – over \$8.2 billion by Australian Bureau of Statistics (ABS) figures for 2010, representing 0.59% of GDP, 69 199 person years of effort³⁵³ and nearly 20% of Australia's expenditure in applied research and experimental development.³⁵⁴

The Australian innovation system relies heavily on the university sector to provide not only its traditional basic research but also for applied research and also for its research workforce. While the Excellence in Research for Australia (ERA) exercise provides a national evaluation of the academic excellence of research from Australian universities there is no equivalent to ensure that the Australian university sector is accountable and systematic in the way it delivers research leading to direct societal impact. Internationally, impact assessment will form part of research evaluation mechanisms in the UK³⁵⁵ and Germany.³⁵⁶

The EIA, then, was a university sector driven trial to demonstrate the feasibility of tracking and assessing research impact. As such, it followed on from the 2005–06 ATN/Murdoch trial conducted as a precursor to unimplemented Research Quality Framework (RQF) which in turn was a model for the impact component of the UK Research Excellence Framework (REF).³⁵⁷

The EIA was a collaboration of 12 universities – Queensland University of Technology, University of Technology Sydney, RMIT University, University of South Australia & Curtin University from the ATN; The University of Queensland, The University of New South Wales, The University of Melbourne & The University of Western Australia from the Go8 and The University of Newcastle, The University of Tasmania & Charles Darwin University – representing 30% of the university sector with a geographical spread and balance of ages and sizes of institutions.

The EIA specified in its terms of reference that it was a trial exercise to measure the innovation dividend of research generated by Australian universities, and as a precursor to a possible companion piece to Excellence in Research for Australia (ERA).

As an exercise designed to assess only research impact and not academic excellence the EIA was able change the standard paradigm of research evaluation – as embodied in exercises such as ERA – in a number of fundamental ways:

- Placing the demonstrated impact of research at the centre of the evaluation with underpinning research assessed in the context of its contribution to the impact.
- Using Socio-Economic Objective (SEO) codes³⁵⁸ – more closely aligned to impact than Field of Research (FoR) codes used in ERA – to define the units of evaluation of the process.

351 Group of Eight & Australian Technology Network (2012) *Excellence in Innovation: research impacting our nation's future – assessing the benefits*, Available at: <http://www.atn.edu.au/eia/Docs/ATN-Go8-Report-web.pdf>.

352 The OECD Main Science Technology Indicators show that in 2008 Australia had 57.7% of researchers in the Higher Education sector.

353 ABS (2010) *Research and Experimental Development*, Higher Education Organisations, Australia, cat. no. 8111.0.

354 ABS (2010) *Research and Experimental Development*, All Sector Summary, Australia, cat. no. 8112.0.

355 <http://www.ref.ac.uk/>

356 <http://www.wissenschaftsrat.de/en/fields-of-activity/research-rating.html>

357 Grant J, Brutscher PB, Guthrie S, Butler L & Wooding S (2010) *Capturing Research Impacts: A review of international practice*, RAND Corporation, Santa Monica, CA, Available at: http://www.rand.org/pubs/documented_briefings/DB578.

358 ABS (2008) *Australian and New Zealand Standard Research Classification (ANZSRC): Socio-economic Objective*, cat. no. 1297.0.





- Each submission comprising a case-study accompanied by supporting indicators. Case studies were used to provide a clear narrative explanation of the impact under consideration accessible to a non-academic audience. Indicators were included to provide a robust, evidentiary validation of the narrative.
- Industry based assessment panels. The EIA had 7 assessment panels, one for Defence and two each for Economic Development, Society, and Environment. The panel membership comprised 70% industry membership with the 30% academic membership to provide expert disciplinary advice to the panels. Each panel was chaired by a high level figure with significant industry experience. Organisations represented on the assessment panels included Chevron, KPMG, Thales, IBM Australia, ConocoPhillips Australia, Microsoft, Deloitte, BHP, Rio Tinto, CSIRO, World Vision and the Salvation Army.

The industry based panels were briefed and met to assess case studies on a five point rating scale A-E with A representing outstanding impact through to E representing limited impact. As indicated by Figure 1 the consolidated panel findings were that nearly 87% of the ratings were at a level of considerable impact or higher.

The EIA final report, approved by the independent EIA Development Advisory Board, Chaired by Mr Philip Clark AM, made 5 key conclusions.

1. It is possible to assess research impact across a broad range of disciplines.
2. The case study approach can provide a compelling narrative of the impact of research.
3. Research impact could be assessed against an outcomes based system of classification such as the ABS SEO code recognising that there are some limitations to this methodology.
4. Expert panels comprising a majority of end-user stakeholders are able to assess research impact. The panels should also include an appropriate discipline mix covering the breadth of research impacts being considered.
5. Development of an impact component of any broader research assessment exercise would require further consideration of the number of case studies to be submitted.

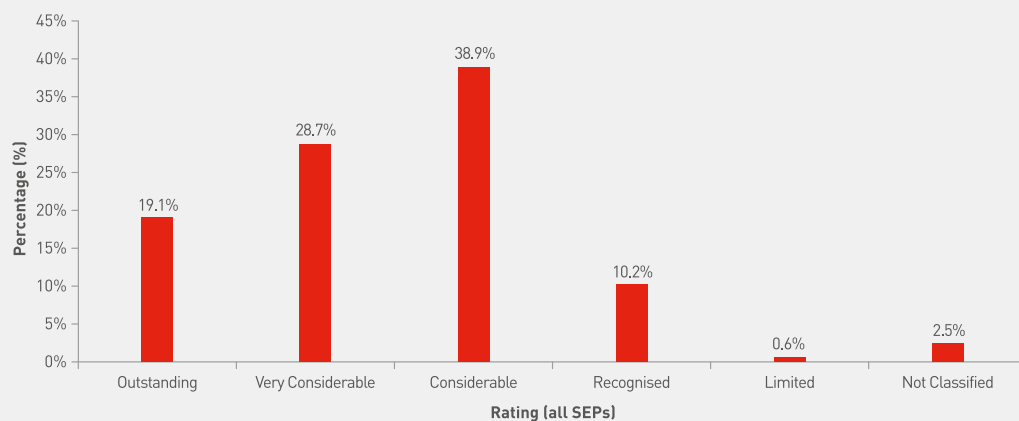
In addition to these conclusions the ATN has commissioned RAND Europe to review the EIA with a report to be published in 2013.

The outcomes of the EIA have been crucial in informing the 2012 DIICCSRTE feasibility study on possible approaches for assessing the wider benefits arising from publicly funded research. The feasibility study in turn has informed the National Research Investment Plan under which a national impact assessment mechanism will be developed in 2013.

Looking forward, the EIA has explicitly demonstrated the contribution of the Australian university sector to the Australian Innovation System and also shown that it possible systematically to assess this contribution.

The next challenge is for the government, universities and industry to work together to develop and use an EIA type mechanism to facilitate and incentivise university research efforts to directly support an innovative and productive Australia.

Chart F4.1 EIA ratings distribution case study ratings by all SEO sectors



Source: Excellence for Innovation for Australia 2012.

Note: SEO stands for Socio-Economic Objective.

FEATURE ARTICLE: OPEN ACCESS PUBLISHING



Dr Danny Kingsley, Executive Officer, Australian Open Access Support Group

Opening up access to publicly funded research outputs has been on an increasing number of political agendas across the world. The issue of unsustainable rising publisher subscription costs to research publications has been flagged since the 1980s. In the intervening period developments in technology such as the advent of the Internet have made the sharing of research outputs both possible and affordable.

Making publicly funded research openly available benefits all of society. The biggest issues the world faces require long term cooperative international research, and research is only effective when other researchers are able to see the outcomes of others' research. As the

total volume and pace of research increases, practitioners in any field need to be able to see the latest (quality assured) findings in order to provide the best service, and unless they have an institutional affiliation, they are unable to do so. Start-up innovation companies need access to research to inform their endeavours. Researchers also benefit from their findings having more exposure. And the taxpayer should be able to look up the latest findings if they wish to, for example to access information about health issues.

The Internet has forever altered the way information is disseminated and accessed. The open access movement has developed databases that specifically allow information to be indexed by search engines, and therefore findable. Called repositories, these can be organised by discipline, for example ArXiv.org³⁵⁹ which caters for the physics community, or can be hosted by an institution as a collection of that institution's research outputs. Most publishers will allow the author's final manuscript version of an article to be placed into a repository although sometimes they require it not be made available for a period of time, called an embargo. The benefit of making work available in this way is the researcher is not compelled to alter their publishing choices, although they may tend towards more permissive publishers.

Another development has been the rise of open access journals. These make research freely available to all readers without a subscription. The majority of these journals are run through smaller society publishers using open source software. There are some commercial open access publishers, including Springer³⁶⁰ and Hindawi.³⁶¹ The Public Library of Science³⁶² is a trailblazer in this field. The multidisciplinary PLOS ONE³⁶³ open access journal launched in December 2006. Within two years it was largest open access journal in the world. In 2010, it was the largest journal in the world (by volume).³⁶⁴ The OA megajournal business model has been embraced by academic authors, and several other commercial publishers have since launched their own versions. Commercial open access publishers charge an article processing fee at the beginning of the publication process rather than charging a subscription for access. Many regular commercial academic publishers now offer open access options.

Over the past seven years many research funding bodies have made open access to research publications a requirement of funding. In 2006 the Wellcome Trust introduced their open access policy³⁶⁵ in the UK, followed by the US National Institutes of Health announcing their Public Access Policy³⁶⁶ in 2008. This trend is increasing exponentially with 2012 seeing the "Report of the Working Group on Expanding Access to Published Research Findings"³⁶⁷ from the Finch Group which recommended all UK research be made available in open access journals. In July the European Commission announced that research funded between 2014 and 2020 under the Horizon2020 programme will have to be open access to "give Europe a better return on its €87 billion annual investment in R&D".³⁶⁸ In the early months of 2013 the Obama administration in the US has released a policy³⁶⁹ requiring all US federal agencies to prepare plans to make research available.

359 <http://arxiv.org>.

360 <http://www.springer.com/open+access?SGWID=0-169302-0-0-0>.

361 <http://www.hindawi.com/>.

362 <http://www.plos.org/>.

363 <http://www.plosone.org/>.

364 <http://blogs.plos.org/everyone/2011/12/20/plos-one-five-years-many-milestones/>.

365 <http://www.wellcome.ac.uk/About-us/Policy/Spotlight-issues/Open-access/index.htm>.

366 <http://publicaccess.nih.gov/>.

367 <http://www.researchinfonet.org/publish/finch/wg/>.

368 http://europa.eu/rapid/press-release_IP-12-790_en.htm.

369 http://www.ip-watch.org/weblog/wp-content/uploads/2013/02/ostp_public_access_memo_2013.pdf.





Domestically, in 2012 the National Health and Medical Research Council (NHMRC) announced its revised policy on the dissemination of research findings,³⁷⁰ effective 1 July 2012. The Australian Research Council (ARC) released its Open Access Policy³⁷¹ on 1 January 2013. Both policies require that any publications arising from a funded research project must be deposited into an open access institutional repository within a 12 month period from the date of publication. There are two minor differences between the two policies. The NHMRC relates only to journal articles where the ARC encompasses all publication outputs. In addition, the NHMRC mandate affects all publications as of 1 July 2012, but the ARC will only affect the outputs produced from the research funded in 2013. Researchers are also encouraged to make accompanying datasets available open access.

Both policies require the deposit of work in the originating institution's open access repository. All universities in Australia host a repository, many of them developed with funds the government provided through the Australian Scheme for Higher Education Repositories (ASHER).³⁷² This scheme which ran from 2007–2009 was originally intended to assist the reporting requirement for the Research Quality Framework (RQF) research assessment exercise, which became Excellence in Research for Australia (ERA). The ASHER program had the aim of “enhancing access to research through the use of digital repositories”.

Repositories in Australia are generally managed by libraries and have been supported by an ongoing organised community. In 2009–2010, the Council of Australian University Librarians (CAUL) established the CAUL Australian Institutional Repository Support Service (CAIRSS)³⁷³ and when central government funding for the service ended, the university libraries agreed to continue the service by supporting it with member contributions. CAIRSS ended in December 2012; however, the email list continues a strong community of practice.

In October 2012 the Australian Open Access Support Group³⁷⁴ launched, beginning staffed operations in January 2013. The group aims to provide advice and information to all practitioners in the area of open access.

Historically Australia has a strong track record in the area of supporting open access. The Australasian Digital Theses (ADT) program began in 2000 as a system of sharing PhD theses over the Internet. The ADT was a central registry and open access display of theses, which were held in self-contained repositories at each university using a shared software platform that had been developed for the purpose. The first theses were made available in July 2000. In 2011, as all these were then being held in universities’ institutional repositories, the ADT was decommissioned. It was estimated that the number of full text Australian theses available in repositories at the time was over 30,000.

The Australian government is investing tens of millions of dollars in developing the frameworks to allow Australian researchers to share their data. The Australian National Data Service (ANDS)³⁷⁵ has responsibility for supporting public access to as much publicly funded research data as can be provided within the constraints of privacy, copyright, and technology. In an attempt to provide a platform for sharing information about data, ANDS has developed a discovery service for data resulting from Australian research, called Research Data Australia,³⁷⁶ which is a national data registry service meshing searchable web pages that describe Australian research data collections supplementing published research. Records in Research Data Australia link to the host institution, which may (or not) have a direct link to the data.

The work of ANDS reflects the broader government position in Australia of making public data publicly available. The Declaration of Open Government³⁷⁷ was announced on July 16, 2010. This policy position is in the process of practical implementation across the country, providing access to information about locations of government services, for example. The level of engagement between government areas and different levels of government varies. Another government initiative has been the Australian Governments Open Access and Licensing Framework (AusGOAL)³⁷⁸ which has an emphasis on open formats and open access to publicly funded information and provides a framework to facilitate open data from government agencies. In addition to providing information and fora for discussion, it has developed a licence suite that includes the Australian Creative Commons Version 3.0 licences.

370 <http://www.nhmrc.gov.au/grants/policy/dissemination-research-findings>.

371 http://www.arc.gov.au/applicants/open_access.htm.

372 <http://www.innovation.gov.au/SCIENCE/RESEARCHINFRASTRUCTURE/Pages/ASHERandIAP.aspx>.

373 <http://cairss.caul.edu.au/cairss/>.

374 <http://aoasg.org.au>.

375 <http://www.andis.org.au/>.

376 <http://researchdata.andis.org.au/>.

377 <http://agimo.gov.au/2010/07/16/declaration-of-open-government/>.

378 <http://www.ausgoal.gov.au/>.

CASE STUDY: ACCELERATING THE INNOVATION PIPELINE FOR MEDICAL BIONIC DEVICES – A NEW COLLABORATION WITH TAIWAN

Australian National Fabrication Facility (ANFF)



Caption: Collaboration participants including Prof Gordon Wallace (ANFF) and Prof Chung-Yu (Peter) Wu (NPNT) at front.

Image provided by the University of Wollongong

Improved patient treatment through the development of medical bionic devices used for drug delivery and nerve and muscle regeneration are future technologies on the horizon in a new Australia-Taiwan collaboration.

The joint venture between the ARC Centre of Excellence for Electromaterials Science (ACES) and three Taiwanese universities has been made possible by public investment in research infrastructure, particularly the Australian National Fabrication Facility (ANFF).

The ANFF links university-based to provide researchers and industry with access to state-of-the-art micro and nano-fabrication facilities. The capability enables users to process hard materials (metals, composites and ceramics) and soft materials (polymers and polymer-biological moieties) and transform these into structures that have application in sensors, medical devices, nanophotonics and nanoelectronics.

The nodes, which are located across Australia, draw on existing infrastructure and expertise. Each offers a specific area of expertise including advanced materials, nanoelectronics & photonics and bio nano applications. The Australia-Taiwan collaboration will focus on:

- Development of wearable medical sensors for use in diagnostics, monitoring and rehabilitation. Examples will include clothing that can collect, store and analyse data from fabric sensors/actuators. Biofeedback from the sensors will be used to modify the clothing properties in real time. These investigations will also examine the use of printed electronics and coupling textile sensors with electronics.
- Development of novel drug delivery systems, such as those for management of epilepsy. Work will focus on improving epilepsy detection and control moving towards improved drug delivery systems for epilepsy patients. Initially this will require the development of valid and reliable prediction models.





- Exploring the integration of optically-induced dielectrophoretic (ODEP) devices and conducting polymer platforms to position cells on conducting polymer electrodes and thereby enable controlled cell stimulation and interrogation.

Academic expertise in nanotechnology and bionics at ACES, as well as the ANFF's Materials Node capabilities at the University of Wollongong (UoW), are at the heart of the collaboration. Examples of the capabilities include fibre/yarn spinning, knitting and braiding facilities for smart textiles; reel-2-reel coating system for printed electronics; and bio-additive fabrication tooling to 3D printing scaffolds for cell regrowth.

These capabilities attracted a Taiwanese delegation led by the Program Director of the National Program on Nano Technology (NPNT), Prof Peter Wu. Following a number of international exchanges, a consortium has been established that includes the ACES and three Taiwanese Universities: National Chiao Tung University, Hsin-Chu University and the National Taiwan University. The purpose of the consortium will be to develop new technologies in these fields and present them as new opportunities for Australian and Taiwanese industry. To formally progress the project a memo of understanding has been signed between UoW and the Taiwanese lead institution, the National Chiao Tung University.

ACES and ANFF Materials Node Director, Professor Gordon Wallace, said "We have been building an innovation pipeline that generates and develops ideas within ACES and gets knowledge about practical advances to the market place as quickly as possible.

"In many projects we will not have all the skills required at hand. The Taiwan electronics industry is globally recognised. If we can couple that expertise to our biomaterials developments we can progress the field of bionics much more effectively.

"Without access to the national facilities provided by ANFF these vital international engagements would not be possible."

For more information visit www.anff.org.au or www.electromaterials.edu.au

CASE STUDY: FINDING ALTERNATIVES TO AIR CONDITIONED FUTURES IN ASIA

By Associate Professor Tim Winter, Institute for Culture and Society, University of Western Sydney

Over the coming two decades Asia will be the main driver of a 40 per cent increase in global energy consumption, more than three quarters of which will continue to come from fossil fuels. For most countries, around half of all carbon emissions come from buildings. For tropical and sub-tropical countries, a significant proportion of that energy consumption is tied to cooling, and across the Asia region this has increased dramatically in recent decades through the introduction of electronic air conditioning. Once regarded as a luxury, air conditioning has now become a near ubiquitous technology for regulating the temperature and humidity levels of interior spaces. Looking forward, the electronic cooling of buildings in Southeast Asia will be a significant factor contributing to a demand in energy that is outpacing much of the world, increasing from current levels by 75 per cent in 2030.



Caption: Comfortable interiors.

In response to these broad trends, Associate Professor Tim Winter and Professor Donald McNeill, from the Institute of Culture and Society, University of Western Sydney were awarded \$195,000 from the ARC in 2012 to work with colleagues from the Department of Architecture, National University of Singapore on alternative, less energy intensive, forms of climate control. Rather than focusing on specific architectural solutions or 'green technologies', the team have developed an innovative, more holistic approach to the problem, by considering the possibilities of reintroducing and maintaining low carbon, tradition based approaches to thermal comfort. The team are building an open access, online knowledge platform that integrates a diverse array of material culture designs – spanning architecture, furniture, clothing, fanning and gardens – with examples of everyday customs, habits and social practices, which together constitute a low carbon 'cool living heritage'.



Caption: Hotel Rooftops, Melaka.





Simultaneously, the project also assesses the real world possibilities and limitations for inserting and maintaining this 'cool living heritage' as an alternative to the energy intensive, highly costly climate control paradigm of AC. With urban modernity almost always associated with increased energy consumption, the interdisciplinary team is working towards understanding the technical, architectural, political, legal, financial and cultural factors, which together bear upon built environment sustainability in Asia in relation to thermal comfort. The aim of developing this innovative approach is to help better identify where and when less energy intensive alternatives to air-conditioning might be implemented.

Three years of funding from the ARC supports a comparison of two very different urban environments, Singapore and Melaka in Malaysia. Over the last five decades the two cities have experienced dramatically different forms of urban development. Singapore is well recognised for its extremely rapid transformation from a 'sleepy backwater' to a modern, globally connected city with 'first world' infrastructures and technologies. The country's first Premier, Lee Kuan Yew has repeatedly suggested air conditioning was an integral technology to the city's economic growth and high-rise development. In distinct contrast, Melaka has remained in large part a low-rise city, retaining significant amounts of its historic architecture. In 2008 it was inscribed on the World Heritage List as a living testimony to the multi-cultural heritage and tradition of Asia. By examining the contrast in the built environment of the two cities, the team is examining the possibilities, opportunities and obstacles for mobilising a cool living heritage within current sustainable urban development initiatives in the two cities.



Caption: A Singapore Mall.

Images provided by Tim Winter.

The project's distinct innovation stems from its goals of moving beyond the common idea that built environment sustainability is essentially a technical, planning or building science issue. By questioning the norms that are now solidifying in Asia around thermal comfort, the project is critically interrogating the opportunities and obstacles for implementing alternatives to air conditioning. In this regard, it tackles an important, but poorly understood, aspect of urban sustainability in Asia.

For more information visit www.socoolh.com or www.uws.edu.au/ics/research/projects_old/cool_living_heritage.

CHAPTER 5: ECO-INNOVATION IN AUSTRALIA

Introduction

The rapid increase in world population, economic expansion and the globalisation of the economy have led to a dramatic growth in the use of natural resources and levels of pollution. These trends have raised concern about the future of living standards with respect to resource depletion and scarcity, climate change,³⁷⁹ costs of environmental degradation, the environmental limits of continued economic expansion,³⁸⁰ and inequalities in access to natural resources across countries.³⁸¹

The size and structure of the economy are fundamentally shaped by the environment. Industry activity is the engine of economic growth and prosperity, but also is the major cause of pollution or unsustainable use of natural resources. For example, industry contributes over 90% of Australia's direct greenhouse gas emissions.³⁸² The top 100 global environmental impacts have been estimated to have resulted in costs of \$US4.7 trillion to society³⁸³ in 2009 alone and at least \$US1 trillion to business in 2013.³⁸⁴ Many primary economic activities may not be profitable if the true costs to the environment were taken into account.³⁸⁵

Australia, like the rest of the world, faces significant environmental challenges from pollution and other forms of environmental degradation, biodiversity loss and unsustainable natural resource use as a result of economic activity.³⁸⁶ Issues such as climate change and environmental water flows through the Murray-Darling Basin River System have been topics of significant public debate between Australian governments, communities and businesses, which demonstrate strong pervasive links between the economy, society and the environment.

Avoiding extreme environmental tipping points, such as fish stock collapse, through mitigation and adaptation activities is a significant domestic and global issue.³⁸⁷ Governments and other organisations have therefore recognised the need to transition to a 'clean', 'green' or 'environmentally sustainable' economy and re-orient Australia's innovation system towards finding the business opportunities in these environmental challenges.³⁸⁸

379 Garnaut R (2011) *Garnaut Climate Change Review 2011: Australia in the Global Response to Climate Change*, Cambridge University Press, Port Melbourne, <http://www.garnautreview.org.au/>.

380 Meadows DH, Randers J & Meadows DL (2004) *Limits to growth: The 30-year update*, Chelsea Green Publishing Company, Vermont, USA; Turner G (2008) *A comparison of the limits to growth with 30 years of reality*, Socio-economics and the environment in discussion CSIRO Working Paper Series 2008-09.

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382 <http://ageis.climatechange.gov.au/ANZSIC.aspx> [Accessed 15 April 2013]. This definition is broad, encompassing all sectors of the economy except Residential.

383 TruCost Plc & The Economics of Ecosystems and Biodiversity Business Coalition (2013) *Natural capital at risk: The top 100 externalities of business*, TruCost Plc, London.

384 Makower J (2013) *State of green business 2013*, GreenBiz Group & Trucost, Oakland, California.

385 TruCost Plc & The Economics of Ecosystems and Biodiversity Business Coalition (2013) *Natural capital at risk: The top 100 externalities of business*, TruCost Plc, London.

386 GHK Consulting in association with Cambridge Econometrics (CE) and the Institute for European Environmental Policy (IEEP) (2007) *Links between the environment, economy and jobs*, GHK Consulting, London.

387 Potsdam Institute for Climate Impact Research and Climate Analytics (2012) *Turn Down the Heat: Why a 4oC warmer world must be avoided*, The World Bank, Washington DC, USA.

388 Climate Commission (2013) *Causes of Climate Change*, <http://climatecommission.gov.au/> [Accessed 27 February 2013]. The Climate Commission was established to provide all Australians with an independent and reliable source of information about the science of climate change, the international action being taken to reduce greenhouse gas emissions, and the economics of a carbon price.

What is Green Growth?

Green economic growth is where the link between economic growth and unsustainable use of natural resources and increasing pollution is broken.³⁸⁹ This requires significant improvement in the productivity³⁹⁰ of carbon, water and other finite natural resources as well as labour productivity.³⁹¹ Improving resource efficiency through adoption of new or existing technology (incremental or disruptive innovation) is not the complete answer. Green growth involves incremental reduction in resource use per unit of value added (relative decoupling) *and* keeping resource use and environmental impacts stable or declining while living standards increase overall (absolute decoupling).³⁹²

Reducing environmental impacts by structural adjustment to lower impact activities in production must outpace growth in consumption, otherwise any gains in efficiency will be eroded by a net increase in environmental impact, i.e. the *rebound effect*. For example, there is a significant body of evidence showing that increasing the efficient production and consumption of energy can drive a rebound in energy demand sufficient to erode much or all of below-cost energy efficiency improvements.³⁹³

Research also shows that per capita environmental impacts rise with higher wealth.³⁹⁴ Rising global affluence (see Chapter 1) leads to rising levels of per capita consumption, with an environmental impact that is magnified by continuing increases in human population.³⁹⁵ More people and particularly more affluent people erode resource efficiency gains in absolute terms. Population and economic growth will therefore lead to higher impacts unless patterns of production and consumption can be changed. While Australia's greenhouse gas emissions generated per dollar of GDP output have declined, net emissions are much higher than they were in 1990 and continue to rise.³⁹⁶ So despite net gains in efficiency, Australia still had a net increase in environmental impact.³⁹⁷

A complete shift to a greener economy therefore depends on *adaptation* or *absolute decoupling*. This requires radical innovations that shift technology paradigms in all fields, redesign markets and push broader social change, including the adoption of different lifestyles and, therefore, consumer preferences.³⁹⁸ So far, most of the global policy focus has been on technology and market design. These will continue to be priorities as more is learned about where best to concentrate innovation investments and how to design markets. However, much greater attention to issues of social design and social innovation over the next 10 to 20 years is expected, much of it focused on liveable cities, since social barriers to adoption are already proving more important than strictly technological barriers.³⁹⁹

Creating a false impression that all businesses must choose between environmental responsibility and economic growth undermines private sector confidence and falsely raises the risk premium on such investments. Through innovation, business sustainability and environmental sustainability are ultimately complementary and there are green growth opportunities in all industry sectors.⁴⁰⁰ Moving to more innovative, environmentally sustainable business practice will be a significant challenge to Australia but if achieved in time will deliver significant competitive advantages. As well as delivering resource (energy, water, material) security that will save industry costs in the long run, investment in green growth is

389 UNEP (2011) *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication – A Synthesis for Policy Makers*, <http://www.unep.org/greeneconomy>, Nairobi, Kenya.

390 Doing more with same or more with less resource inputs.

391 Janeway WH (2013) *Speech to Investing to Promote Innovation and Sustainability*, United States Studies Centre and the University of Sydney Business School.

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398 OECD (2010) *Eco-innovation in Industry: Enabling green growth*, OECD Publishing, p.46; Cheam J (2013) Redefining status symbols, *Eco-Business magazine*, 3 July 2013 www.eco-business.com/opinion/redefining-status-symbols; Witt U (2011) The dynamics of consumer behaviour and the transition to sustainable consumption patterns, *Environmental Innovation and Societal Transitions*, 1(1), 109–114; Mont O, Vitae A & Plepys A (2008) Sustainable consumption progress: should we be proud or alarmed? *Journal of Cleaner Production*, 16(4), 531–537.

399 Bai X, Fragkias M, Gutscher H, Duraipapp AK, Neskakis LJ & Scherkenbach C (2012) *Human well-being for a planet under pressure*, Rio+20 Policy Brief #6, International Human Dimensions Programme on Global Environmental Change; see also www.ihdp.unu.edu/green-economy.

400 Business Council of Australia President Tony Shepherd, *Speech to the National Press Club*, 17 April 2013; Knowles V, Henningsson S, Youngman R & Faulkner A (2012) *Coming Clean: The Global Cleantech Innovation Index 2012*, Cleantech Group and World Wildlife Fund; Makower J (2013) *State of green business 2013*, GreenBiz Group & Trucost, Oakland, California; Business and Industry Advisory Committee to the OECD (2013) *Policy position on the OECD Green Growth Strategy*, <http://www.biac.org/policygrp/profile-ggs.htm> [Accessed 30 May 2013].

generating significant returns from a fast-growing global market for resource-efficient activities (see section below on green growth opportunities in Asia).⁴⁰¹

Australia has some critical choices to make about how it will foster economic growth in a possible future economic climate, where jobs and capital may be in short supply. The rest of the world seems to be shifting towards more resilient⁴⁰² greener economies faster than Australia (see below), so can and should Australia be fostering innovation to generate a new set of green growth-driven companies and avoid being locked out of this new source of wealth?

Measuring a transition to green growth

A number of international and domestic organisations are attempting to measure environmentally sustainable growth and eco-innovation in Australia.⁴⁰³ The Australian Bureau of Statistics has made important steps towards environmental accounting through its recent *Completing the Picture* report.⁴⁰⁴ Table 5.1 shows a number of broad indicators of Australia's transition to a green growth economy, compared with other OECD countries. These indicators mostly measure resource productivity (relative decoupling) across different OECD countries i.e. output per unit resource input. Since 1995 Australia has shown progress in its transition to a green growth economy. The economy has become more resource-efficient in this period; this is a positive trend (Table 5.1). In the last ten years, Australia has increased its GDP with no net growth in greenhouse gas emissions to 2011–12 due to reduced deforestation and increased plantation forestry, significant increases in renewable energy, a drop in demand for grid-supplied electricity and a tripling in the rate of energy efficiency improvement in large industrial companies.⁴⁰⁵

Despite these improvements, Australia rates relatively poorly on resource productivity compared to other OECD economies (Table 5.1). Australia's carbon dioxide (CO₂), energy and material resource productivity measures rank at the bottom of the OECD. Even in areas where Australia has a good reputation in managing scarce resources such as water productivity we only rank 19th. In the case of energy efficiency this result holds true even after taking account of industrial structure.⁴⁰⁶ Energy intensity is higher than the OECD average (Table 5.1). The International Energy Agency notes that this is largely due to Australia's relatively low energy prices, long transport distances and energy-intensive industrial structure.⁴⁰⁷ Not surprisingly then, Australia's world ranking by the Environmental Performance Index is also low (Table 5.1). Australia currently ranks near the bottom of developed countries (29th out of 32 OECD countries) in environmental performance in terms of Total Ecological Footprint (6.83 global hectares per person).⁴⁰⁸

Chart 5.1 shows the trends in Australia's production-based carbon dioxide productivity compared with other countries around the world. Although back in the early 1970s Australia was on par with Europe and ahead of the Americas, this position has worsened in the last 40 years such that Australia now lags well behind other developed countries in its transition to a green economy. Australia has one of the world's highest per capita greenhouse gas emissions⁴⁰⁹ and a rate of production-based carbon dioxide productivity improvement that is lagging behind the rest of the developed world (Chart 5.1). Europe has the highest level of carbon productivity of those regions observed in Chart 5.1, in part due to it progressing further in the transition to a green growth economy than Australia. The data shows a period in Australia's history prior to the introduction of carbon pricing and a range of complementary policies designed to encourage innovation and structural shifts to less polluting industries. More recent data that does not yet have international comparisons shows that both the price on carbon and the renewable energy target are starting to transition the economy to a lower carbon intensity.⁴¹⁰

401 Better design and more efficient use of materials could lead to an annual economic boost of up to US\$630bn a year towards 2025 in the European Union alone. See Ellen MacArthur Foundation (2012) *Towards the Circular Economy: Economic and business rationale for an accelerated transition*, <http://www.ellenmacarthurfoundation.org/circular-economy/circular-economy/towards-the-circular-economy> [Accessed 30 May 2013].

402 Cleantech energy investments withstood the global financial crisis relatively well, with investment dropping only 6.6% compared to 19% for the oil and gas industry. *Source*: The Pew Charitable Trusts (2010) *Who's winning the clean energy race?*, The Pew Charitable Trusts, Washington DC.

403 UNU-IHDP and UNEP (2012) *Inclusive Wealth Report 2012: Measuring progress toward sustainability*, Cambridge University Press, Cambridge; National Sustainability Council (2013) *Sustainable Australia Report 2013*, Conversations with the future, Canberra, DSEWPac.

404 ABS (2012) *Completing the picture – Environmental accounting in practice*, cat. no. 4628.0.

405 ClimateWorks Australia (2013) *Tracking Australia's progress towards a low carbon economy*, ClimateWorks Australia, Melbourne.

406 Australian government (2010) *Report of the Prime Minister's Task Group on Energy Efficiency*, Prime Minister's Task Group on Energy Efficiency, Canberra, pp.26–27.

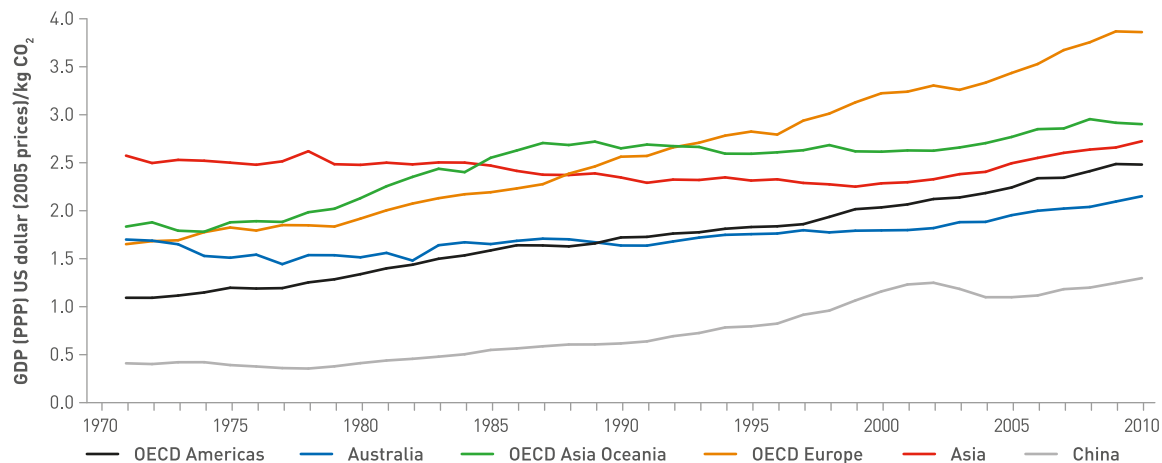
407 International Energy Agency (IEA) (2009) *Implementing energy efficiency policies 2009: Are IEA member countries on track?* OECD & IEA, Paris p.53.

408 Global Footprint Network (2012) *The National Footprint Accounts*, 2011 edition, Global Footprint Network, Oakland, California.

409 Australian Government (2013) *How Australia's carbon price is working one year on*, June 2013, DIICCSRTE, Canberra.

410 *Ibid.*

Chart 5.1 GDP per CO₂ emissions using purchasing power parities, Australia and selected regions, 1971–2010



Source: International Energy Agency (2012) *CO₂ Emissions from Fuel Combustion 2012 Edition*, IEA, Paris.

Note: *OECD Americas* includes Canada, Chile, Mexico and the USA. *OECD Asia Oceania* includes Australia, Israel, Japan, Korea and New Zealand. *Asia* includes Bangladesh, Brunei Darussalam, Cambodia, Chinese Taipei, India, Indonesia, Korea, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Thailand and Vietnam. *OECD Europe* includes Austria, Belgium, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland Ireland, Italy, Luxembourg, Netherlands, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom. *China* includes China and Hong Kong.

Table 5.1 Green growth indicators

Indicators	Australian trend data ⁽ⁱ⁾										OECD comparison					
	1995	2000	2005	2006	2007	2008	2009	2010	2011	2012	Australia's score ⁽ⁱⁱⁱ⁾	OECD average ⁽ⁱⁱⁱ⁾	OECD top 5 average ^(iv)	Gap from the top 5 OECD performers ^(v) (%) ^(vi)	Ranking against OECD countries ^(vi)	
Production-based CO ₂ productivity, \$US per kg CO ₂ ^{1.(a)}	1.68	1.73	1.87	1.9	1.94	1.97	2.01	2.06	-	-	2.06	3.66	6.01	66	33rd	
Energy productivity, US\$ per kilotonne oil equivalent ¹	5.19	5.42	6.06	6.12	6.22	6.13	6.13	6.34	6.75	-	6.75	7.74	10.96	38	22nd	
Renewable energy supply, %Total Primary Energy Supply ¹	5.98	5.88	5.65	5.72	5.74	5.68	5.49	5.51	6.13	-	6.13	15.35	44.95	86	25th	
Non-energy material productivity, US\$ per kg ^{1.(b)}	0.72	0.73	0.84	0.92	0.92	0.94	-	-	-	-	0.94	2.22	4.37	78	32nd	
Non-energy material productivity excluding construction materials and fossil fuels, US\$ per kg ¹	0.96	0.94	1.04	1.16	1.19	1.17	-	-	-	-	1.17	6.24	11.74	90	32nd	
Biotic material productivity including wood and biomass for food and feed, US\$ per kg ¹	1.73	1.99	2.28	2.73	2.73	2.71	-	-	-	-	2.71	8.79	18.5	85	33rd	
Abiotic material productivity including industrial minerals and metals, US\$ per kg ¹	2.16	1.77	1.93	2.02	2.1	2.07	-	-	-	-	2.07	25.39	58.98	96	31st	
Water productivity, total (constant 2000 US\$ GDP per cubic meter of total freshwater withdrawal) ²	16.4*	19.5**	-	-	23.1	-	-	-	25.4	-	25.4	70.2	224.6	89	19th	
Public spending in environment-related R&D, % total public spending on R&D ^{1.(c)}	1.19	2.95	3.18	3.29	3.81	3.57	5.47	5.01	4.86	-	4.86	2.41	4.5	No gap	2nd	
Green Patents, Index 1990=100 ^{1.(d)}	206	339	546	440	653	655	661	460	-	-	460	1638	4538	85	19th	
Total environment related taxes, % GDP ^{1.(e)}	2.57	2.4	2.2	2.09	2.01	1.89	1.89	1.83	-	-	1.83***	2.26	3.63	49	27th	
World ranking by the Environmental performance Index ³	-	30th	42nd	42nd	42nd	47th	48th	48th	-	48th	-	-	-	-	-	28th
Annual growth in per capita natural capital, % ⁴	-1.63	-1.39	-1.66	-2.65	-2.78	-2.78	-	-	-	-	-2.78	-1.45	-0.62	349	8th ^y	
Proportion of innovation-active businesses innovating to reduce environmental impacts, % ⁵	-	-	-	-	12.1	-	11.4	-	12.9	-	-	-	-	-	-	-

Sources: [1]. OECD Green Growth indicators database. [2] World Bank World Development Indicators. [3] Yale University and Columbia University, in collaboration with the World Economic Forum and the Joint Research Centre for the European Commission, Environment Performance Index 2012. [4] UNU-IHDP and UNEP (2012) Inclusive Wealth Report 2012. Measuring progress toward sustainability. Cambridge: Cambridge University Press. [5] ABS (2012) *Innovation in Australian business, 2010–11*, cat. No. 8158.0.

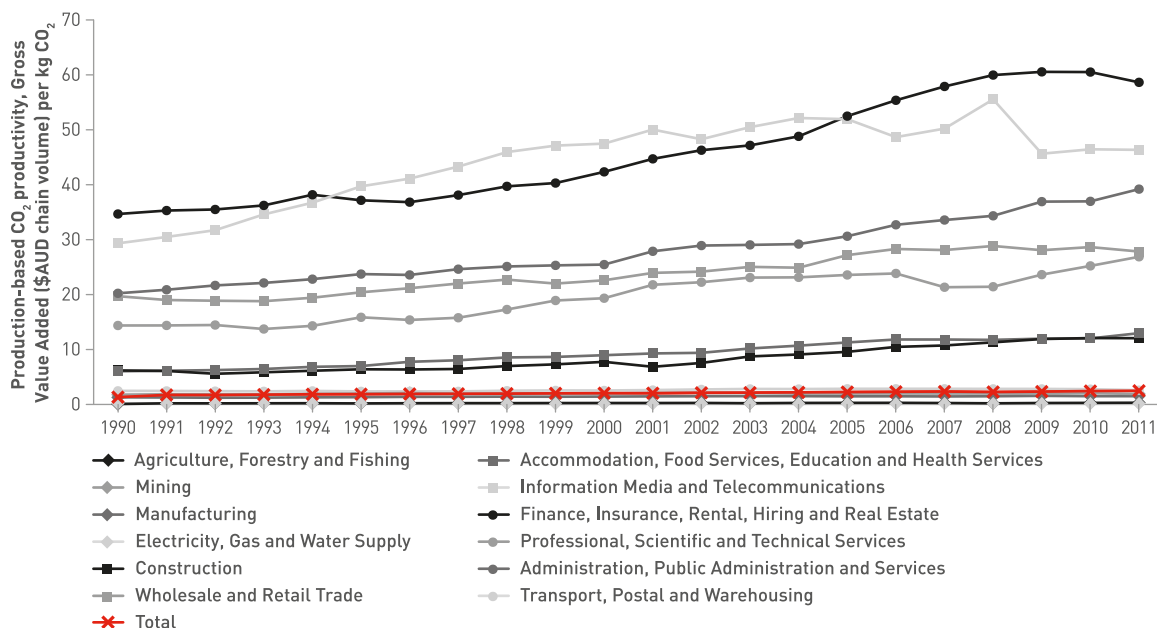
Indicator notes: (a) Production based CO₂ productivity is measured by GDP generated per unit of CO₂ emitted for the period 1990 to 2008. The CO₂ emissions presented here are gross direct emissions, emitted within the national territory and excluding bunkers, sinks and indirect effects. (b) Non-energy materials include biomass for food and feed, wood, construction minerals, industrial minerals, and metals. (c) Government appropriations or outlays for research and development sourced from GBAORD by socio-economic objective (SEO) - Environment, using the NABS 2007 classification. The indicator is expressed as a % of all-purpose government outlays for R&D. (d) Patent applications filed (priority date) under the Patent Cooperation Treaty (PCT) using inventor's residence. Total "green" patents comprise patents in climate change mitigation and energy and pollution abatement and waste management. (e) Environmentally related taxes include taxes on energy products (for transport and stationary purposes including electricity, petrol, diesel and fossil fuels), motor vehicles and transport (one-off import or sales taxes, recurrent taxes on registration or road use, other transport taxes), waste management. * Value is for 1997. ** Value is for 2002. *** Value is for 2010. (y) Ranking out of eight OECD countries.

Table notes: (i) Data is presented in calendar year format. Where the data is in financial years, it is expressed in terms of the year where the financial year begins e.g. 2010-11 is shown as 2010. (ii) The 'Australia's score' field presents the Australian values used in the OECD comparisons. (iii) This is the arithmetic (simple) average of the OECD country scores. (iv) This is the arithmetic (simple) average of the top five OECD countries in a ranked list. (v) This represents Australia's distance from the frontier as defined by the average of the top five ranked OECD countries. It is calculated as $100 * (\text{Top five average} - \text{Australia's score}) / \text{Top 5 average}$. Where the solution is a negative value or zero, "no gap" is shown in the cell. (vi) OECD rankings are performed on those OECD countries for which data is available. Individual data availability may vary between indicators. "-" = data not available.

When comparing Australia with other advanced countries it is important to consider Australia's industrial structure which historically has had a relatively high dependence on its resource sector and energy intensive industries for wealth generation.⁴¹¹ Chart 5.2 and 5.3 show that Australia's poor environmental performance is not uniform across all Australian industries. In many cases, the service sectors generate the most output per unit of natural capital, however, they often rely heavily on intermediate outputs of other sectors such as manufacturing. Improving resource productivity over time is occurring for most sectors but clearly the aggregate effort is flagging behind other countries due to the more resource-intensive, highly polluting sectors. Importantly, the resource-intensive, poorer performing sectors are often the ones more likely to be undertaking environmental management activities or investing in innovation for environmental reasons (see discussion below).

Analysis of the structural factors underlying Australia's poor environmental performance shows that the resource-intensive sectors, notably agriculture, mining, manufacturing, transport and utilities are responsible for our relatively poor international performance. Their production-based resource productivity is relatively low and most changed very little over the last 20 years. The services sector are usually high performers on production-based resource productivity (Charts 5.2 and 5.3). Their production-based resource productivity is high and doubled in sectors such as construction over the last 20 years.

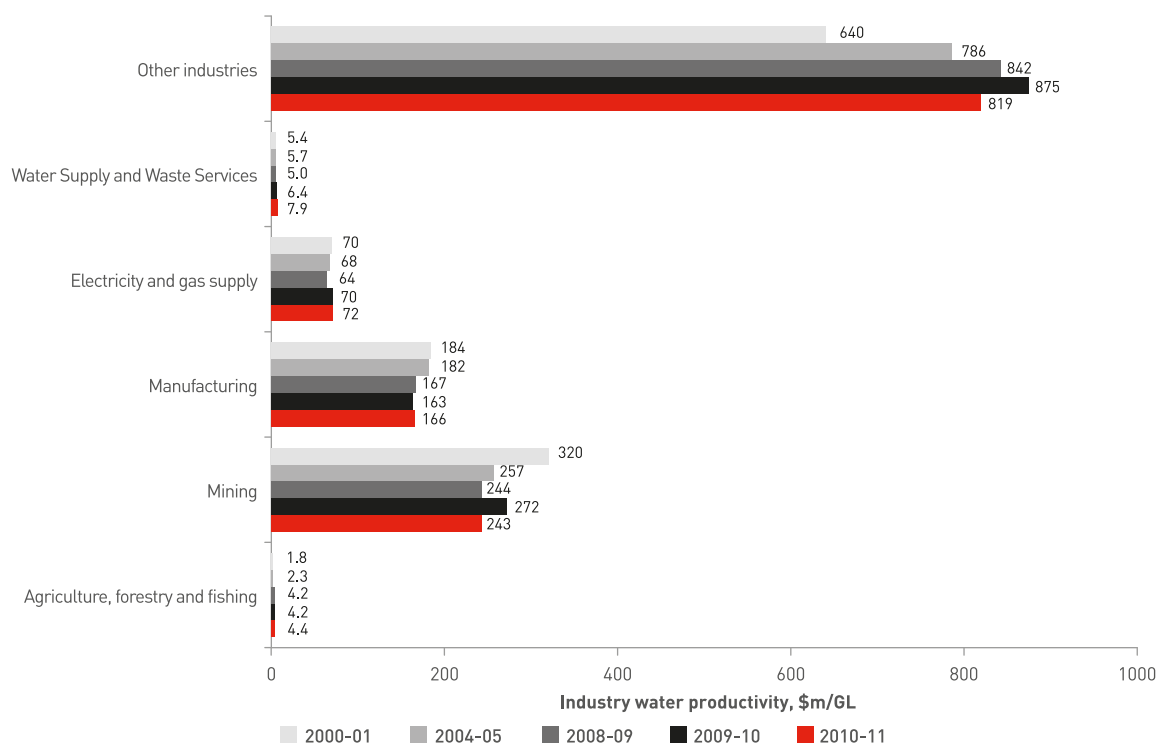
Chart 5.2 Australian CO₂ Productivity by industry sector, 1990–2011



Source: ABS (2013) *Australian system of national accounts*, cat. no. 5204.0; DIICSRTE (2013) *National Greenhouse Gas Inventory*.

⁴¹¹ Australian government (2010) *Report of the Prime Minister's Task Group on Energy Efficiency*, Prime Minister's Task Group on Energy Efficiency, Canberra, pp.26–27.

Chart 5.3 Industry gross value added per Gigalitre (GL) of water consumed, 2000–01 to 2010–11



Source: ABS (2012) *Water Account Australia, 2010–11, 2004–05 and Water Account for Australia 1993–94 to 1996–97*, cat. no. 4610.0; ABS (2013) *Australian National Accounts: National Income, Expenditure and Product, Mar 2013*, cat. no. 5206.0

Resource productivity changes across the OECD are the result of not only eco-innovation, but also the structural adjustment of industry to less-polluting activities. Outsourcing of resource intensive economic activities through international trade also leads to an improvement in the resource productivity numbers.⁴¹² Australian energy consumption data highlights the importance of innovation and structural change in reducing our impact on the environment. Far and away the largest driver of energy consumption in industry is demand, doing more of everything in the face of population growth and rising affluence. Australian industry consumed 963 petajoules of energy between 1989–90 and 2009–10.⁴¹³ Offsetting this consumption was an energy efficiency effect and structural change savings. The efficiency effect (that can be attributed in part to technology acquisition and other non-technological innovation) in industry resulted in a decrease in energy use of 201 petajoules between 1989–90 and 2009–10. The structural effect was responsible for a reduction in energy use of 109 petajoules.⁴¹⁴ The stronger energy efficiency effect must be recent as previous reports have suggested a rapid switch in Australia away from energy-intensive manufacturing and towards a services-based economy (which is less energy intensive) may have masked relatively slow changes in energy efficiency within sectors relative to developments elsewhere.⁴¹⁵

There is growing international consensus that the world must move beyond GDP as a measure of progress and wellbeing to take into account environmental impacts. The United Nations has been developing new accounting methods for valuing the natural environment (so called natural capital)⁴¹⁶ in financial measurements of wealth creation. Unpriced natural capital costs for over 1,000 global primary production and primary processing⁴¹⁷ activities were costed at US\$7.3 trillion in 2009 by a United Nations business coalition.⁴¹⁸ Most striking is that, according to this United Nations sponsored methodology, environmental costs were higher than revenue for all but five (iron and steel manufacturing, cement, crude oil and gas extraction, natural gas power generation and fishing) of the 20 region-sectors analysed. None of these

412 <http://www.seri.at/> (Sustainable Europe Research Institute). <http://www.materialflows.net/> is an online portal for material flow data, providing access to material flow data sets on the national level [Accessed 5 March 2013].

413 Che N & Pham P (2012) *Economic analysis of end-use energy intensity in Australia*, Bureau of Resources and Energy Economics, Canberra.

414 *Ibid.*

415 Australian government (2010) *Report of the Prime Minister’s Task Group on Energy Efficiency*, Prime Minister’s Task Group on Energy Efficiency, Canberra, p.29.

416 Such as fossil fuels, cropland, forests and fisheries.

417 Relates to region-sectors under standard operating practices, excluding unpredictable catastrophic events.

418 TruCost Plc & The Economics of Ecosystems and Biodiversity Business Coalition (2013) *Natural capital at risk: The top 100 externalities of business*, TruCost Plc, London.

region-sectors would be profitable, let alone cover the cost of capital after environmental impacts are taken into account.⁴¹⁹

Results for Australia for the period 1990 to 2008 indicate that while our GDP per capita growth was 47%, Australia's growth under the Inclusive Wealth Index (IWI)⁴²⁰ was only 2% over the same period. The significant difference between this Index and GDP per capita can be explained by an estimated 27% per capita depreciation of our natural capital (as assessed using the IWI methodology). Chart 5.4 illustrates the average annual contribution of the different capital types to the development of the per capita IWI. It shows that many countries that have improved their wellbeing, i.e. positive 'inclusive growth,' have done so at the expense of their natural assets. Australia is one of the worst performing developed countries by these standards. These trends pose risks to future economic growth in Australia and suggest that continued prosperity requires Australia to increase its investments, especially in natural capital stocks, through innovations that increase biodiversity conservation, improve water resources, increase soil carbon and ensure the sustained viability of fish stocks.⁴²¹

The importance of innovation in a transition to a green economy

It has been argued that the next global wave of innovation will be about maximising resource efficiency and minimising waste and pollution in the consumption-production cycle.⁴²² Recent research suggests that both climate change (and associated risks) and inadequate investment in innovation (particularly R&D) are the two highest rated risks to Australia's future prosperity in terms of both expected severity and likelihood of occurrence.⁴²³ Combining these two national risks together there is a strong argument for increasing and sustained investment in eco-innovation.

Addressing major environmental issues (as outlined above) will be very difficult and costly without innovation.⁴²⁴ Business survival or performance in the long term is about adaptation in the face of change. The only way to get away from environmentally unsustainable 'business as usual' practices is to innovate. Existing production technology, business models and consumer behaviour can only be expected to produce positive outcomes up to a point beyond which depleting natural capital has negative consequences for overall growth. By pushing the frontier outward, innovation will help decouple natural capital depletion from economic growth in absolute terms. In so doing eco-innovation and green entrepreneurship will create new markets and new jobs. The potential spill over effects of eco-innovation could be larger than other forms of innovation because the market is still underdeveloped and the potential for growth may be large.⁴²⁵ It is therefore positive that global investment in clean energy innovation is accelerating⁴²⁶ and that drivers for green growth are currently strong in Australia and elsewhere.⁴²⁷ Global private investment in eco-innovation was estimated at US\$4.1 trillion between 2007 and 2012.⁴²⁸ Cumulative investment in eco-innovation is expected to reach \$10 trillion by 2020.⁴²⁹

419 *Ibid.*

420 National Sustainability Council (2013) *Sustainable Australia Report 2013*, Conversations with the future, Canberra, DSEWP&C.

421 *Ibid.*

422 Moody JB & Nogrady B (2010) *The sixth wave: How to succeed in a resource-limited world*, Random House, Australia; Sissons A (2011) The next wave of innovation: Five areas that could pull the UK clear of recession, Big Innovation Centre, London.

423 KPMG (2012) *2012 Australia Report: Risks & opportunities*, ADC Forum & KPMG, Melbourne.

424 OECD (2011) *Fostering Innovation for Green Growth*, OECD Publishing.

425 *Ibid.*, p.23.

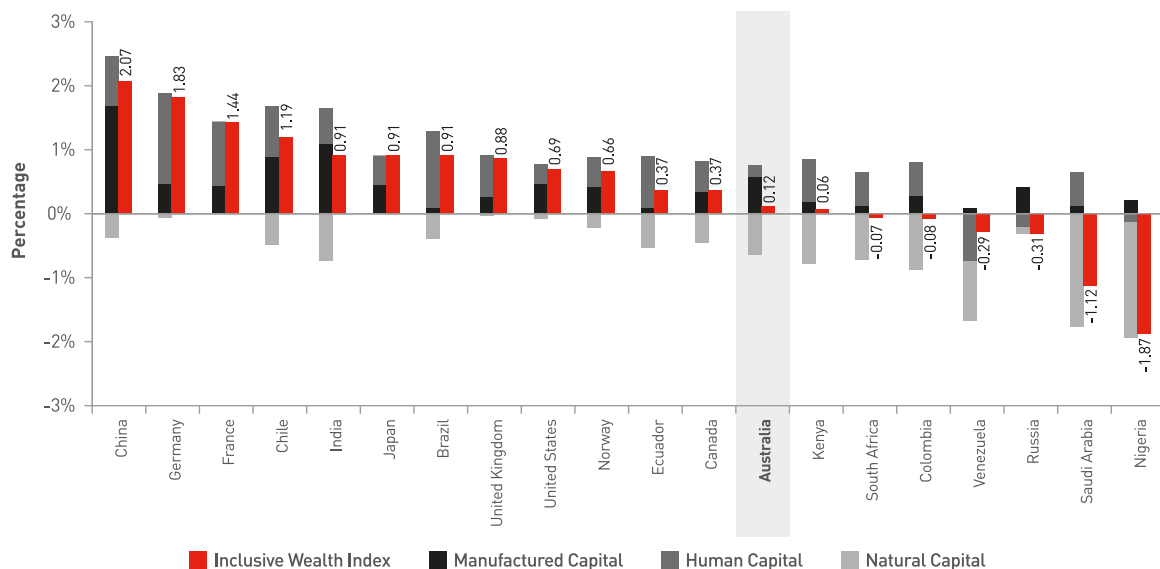
426 International Energy Agency (IEA) (2013) *Tracking Clean Energy Progress 2013*, OECD & IEA, Paris.

427 Godfrey B, Sargent M & Pond S (2013) *Green growth – Energy: Industry opportunities for Australia*, Australian Academy of Technological Sciences and Engineering, Melbourne.

428 Henderson H, Sanquiche R & Nash T (2013) *Green Transition Inflection Point: Green Transition Scoreboard® 2013 Report*, Ethical Markets Media, February 2013.

429 Montalvo C, Diaz-Lopez F & Brandes F (2011) *Potential for eco-innovation opportunities in nine sectors of the European economy*, European Sectoral Innovation Watch, European Commission, Brussels.

Chart 5.4 Average annual growth rates in Inclusive Wealth Index (per capita) disaggregated by capital form, by country, 1990–2008



Source: UNU-IHDP and UNEP (2012) *Inclusive Wealth Report 2012. Measuring progress toward sustainability*. Cambridge: Cambridge University Press. <http://www.ihdp.unu.edu/article/iwr>

FEATURE: SUSTAINABILITY AND INNOVATION – PREPARING FOR GROWTH



By Andrew Petersen, CEO, Sustainable Business Australia

The global economy is in recovery, albeit a timid one. Worldwide, the middle class is expanding by an estimated 100 million per year. The quality of life for millions in Asia and Africa is growing at an unprecedented pace.

In Australia, the productive yield of the commodities that have built our success story – coal, wheat, sheep, ore – are reliant on our natural resources which are all experiencing unprecedented impacts and challenges.⁴³⁰

Australia, along with the rest of the world, is faced with a conundrum: how do we innovate to drive growth without creating bubbles and instead achieve widespread prosperity, without consuming more natural resources than we have or can regenerate?⁴³¹ This conundrum is forcing governments, business leaders and civil society across the world to think differently about how they will achieve growth. This thinking has leading economic think-tanks and international agencies, like the OECD and the IMF, calling for a transition to a global economy that maximizes well-being, operates within environmental limits and is capable of coping and adapting to global environmental change – a “green” economy.

An economy in transition

The concept of a green economy brings with it the promise of a new economic growth paradigm that is responsive to the earth’s ecosystems and can also champion human development.

430 Hajkowicz SA, Cook H, Littleboy A (2012) *Our Future World: Global megatrends that will change the way we live*, The 2012 Revision, CSIRO, Melbourne.
 431 National Sustainability Council (2013) *Sustainable Australia Report 2013*, Conversations with the future, Canberra, DSEWPaC.



The rationale for this transition includes policies, programs and market-based mechanisms that will assist the deployment of renewable resources, energy conservation and technologies for sustainable future development. Sustainable systems of production and consumption are already being reached through technology and innovation. However, the scale and pace of investment, innovation, technology development and employment creation required is beyond the capacity and responsibility of governments alone.

Many in the corporate world view with a growing unease the fluctuating dynamics of today's business landscape and the uncertainty over the path forward. At the same time, a growing business momentum is starting to recognise and address this complexity by viewing the synergies that prevail over the trade-offs. They are doing this by incorporating sustainability factors into their corporate plans and score cards, such as cutting-edge sustainability technology, and exploring other innovative ways and opportunities to innovate. This action will play a crucial role in enhancing people's lives and improving national productivity, economic growth and competitiveness, with good returns on capital investments for shareholders and investors, including governments.

Asia's Environment is Australia's Economic Future

Into this context is the Asian economic boom of recent years that has led to soaring demand for Australia's natural resources, such as iron ore, coal and copper. This has led to what some in academic and business circles have termed China's energy or growth trilemma: resource scarcity, environmental protection and economic growth.⁴³² Related to this force is a signal from findings in 2012 survey work by the Massachusetts Institute of Technology that emerging markets' commitment to sustainability is increasing at a faster pace than in developed countries.⁴³³

Combined, these trends – which are both indications of the externalities associated with economic growth – must be seen in the lens of opportunity for Australian enterprise, innovation and investment. For example, the Chinese Government has committed to the pursuit of urbanisation that emphasizes environmental sustainability and the establishment of a green economy. Into this new urban environment there will be more people than ever, consuming more products.⁴³⁴ Importantly that consumer is a very different one to the consumer from the developed world. She, or he, is younger, online, connected and more likely to take brands to task for their failures or shortcomings. A 2012 World Economic Forum study noted that these emerging market "Millennials" are three times more likely to text about a brand's environmental or social shortcomings than their developed country counterpart.⁴³⁵

This new world consumer provides a significant growth opportunity for smart Australian businesses that can demonstrate the sustainability of their products and bring them to market quickly. Opportunities already exist for developing and commercialising value-added "clean and green" individually-branded Australian products for export.

Presented by rapid urbanisation in parts of Asia where green infrastructure and construction projects are required, many commercial partnerships will become available for Australian construction and engineering businesses that use sustainable processes, products and equipment. Australian businesses also have a competitive edge due to their recognised leadership in ecologically sustainable design initiatives and building green, according to a recent Global Real Estate Sustainability Benchmark report.⁴³⁶ For example Grocon's Pixel Building, in Melbourne, Victoria, has been acknowledged as the first carbon neutral office building of its kind in Australia when it received the world's highest Leadership in Energy and Environmental Design rating by the US Green Building Council.⁴³⁷

432 Klingholz R & Töpfer K (2012) *The Growth Trilemma, Population Growth, Energy Consumption and Climate Change—Three Problems, No Solution?*, The Berlin Institute for Population and Development, Berlin.

433 Haanaes K, Reeves M, von Streng Velken I, Audretsch M, Kiron D and Kruschwitz N (2012) *Sustainability & Innovation [Sustainability Nears a Tipping Point] Section II: Ahead of the Game: The Leaders in Sustainability*, Research Report Winter 2013, MIT Sloan Management Review and The Boston Consulting Group, Cambridge.

434 Chun N (2010) *Middle Class Size in the Past, Present and Future: A Description of Trends in Asia*, Asian Development Bank Working Paper Series No. 217, Asian Development Bank, Manila, Philippines.

435 World Economic Forum (2012) *More with Less: Scaling Sustainable Consumption and Resource Efficiency*, World Economic Forum, Geneva, Switzerland.

436 Global Real Estate Sustainability Benchmark (2012) *Global Real Estate Sustainability Benchmark Report*, <http://gresb.com/benchmark/> [Accessed 9 May 2013].

437 LEED scorecard directory. <http://www.usgbc.org/projects/pixel-0> [Accessed 9 May 2013].





On the topic of innovation in skills training, Australia's international education sector is very active in China, tailoring its activities to suit demand. For example, responding to the growing push in China for green skills and sustainable development, TAFE Directors Australia and the China Education Association for International Exchange jointly sponsored and managed a Green Skills forum in Beijing in late 2012.

Business and the Innovation Quotient

Knowledge and innovation are key success factors for adding value and achieve sustained growth in an increasingly complex and globalised economy. Recently the Harvard Business Review claimed "...[s]mart companies now treat sustainability as innovation's new frontier."⁴³⁸ Overseas a growing number of corporations are re-evaluating the challenges by utilizing the sustainable development agenda as a "design brief" for their innovation laboratories.⁴³⁹

Companies in emerging countries, as stated earlier, have numerous reasons to develop robust sustainability agendas, which in turn will drive a need for environmental goods and services and a need to address environmental degradation, such as a lack of clean water and other forms of pollution, in the areas where they operate.

Australian and New Zealand based companies are leading the way when it comes to adapting their business models to include sustainability goals.⁴⁴⁰ At the same time, Australian industry and business leaders are emerging who believe innovation will help their companies make dramatic improvements to their environmental and social impacts, balanced with financial savings and increased export values.⁴⁴¹

For example, adopting innovative approaches will enhance the ability of Australia to supply our food to the world. The 2012 Red Meat Processing Industry Climate Change Strategy, a joint initiative of the Australian Meat Processor Corporation and the Australian Meat Industry Council, with input from Sustainable Business Australia developed an industry wide-approach to manage and mitigate climate change through the implementation of activities that will enable red meat processing businesses to proactively participate in a global low carbon economy.⁴⁴² To achieve this, they have set several industry specific targets for water management, energy efficiency and greenhouse gas emissions reduction across the industry.

Other examples of agricultural innovation are being generated through our research institutions, working with industry, and they include the development of drought resistant crops, low-rainfall farming practices and high-efficiency irrigation, through to innovative market research and value chain analysis.

Across Australia, collaborative models are emerging and already locating and implementing pilot and commercial-scale green projects in partnership with industry and with support from government. The Cleantech Industries Sunshine Coast Inc, formerly the Sunshine Coast Cleantech Cluster, in Queensland, was established two years ago with initial local and state government funding, and by a unique collaboration through businesses, local government and the Sunshine Coast University. The cluster works to position and market this Queensland region as a nationally and globally significant commercial hub for cleantech demonstration projects, innovation, finance, investment, commercialisation and deployment into business and government operations. It also builds local and national networks and facilitates the sharing of information to educate stakeholders on the benefits of adopting and investing in clean, sustainability technologies, such as water management, environmentally sustainable building design and products, manufacturing and industrial processes, energy efficiency, and environmental consulting. They have slowly begun to enable resources, knowledge, investment and business opportunities to be realised more effectively and faster than if companies proceeded on their own.⁴⁴³

438 Nidumolu R, Prahalad CK & Rangaswami MR [2009] Why sustainability is now a key driver of innovation, *Harvard Business Review*, 87(9), 57–64.

439 Metcalfe D, Curtis A, Hotchkiss L, Jowett G [2012] *Green game-changers: Insights for mainstreaming business innovation*, WWF—UK, Surrey.

440 Kiron D, Kruschwitz N, Haanaes K, Reeves M & Goh E [2013] *The Innovation Bottom Line, Research Report Winter 2013*, MIT Sloan Management Review and The Boston Consulting Group, Cambridge.

441 ICN clean tech directory <http://cleantech.icn.org.au/> [Accessed 8 May 2013].

442 Australian Meat Processor Corporation (AMPC) [2012] *Red Meat Processing Industry: Climate Change Strategy, Version 1—2012*, AMPC, St Leonards NSW.

443 www.cleantechindustries.com.au [Accessed 8 May 2013].





Business is also investing in future innovators. The Australian's 2012 Innovation Award, in association with Shell⁴⁴⁴ and the GE 2013 Ecomagination Challenge are two recent examples of where larger companies believe in innovation and recognise its importance for the nation, while shining a spotlight on the creative and innovative work taking place.

In the case of GE's 2013 Ecomagination Challenge, five home-grown low-carbon innovations were the winners across Australia and New Zealand. The awarded technologies ranged from a carbon-free alternative for internal combustion and electric motors, to wave energy, water treatment membranes, smart water meters, and an advanced energy network planning tool.⁴⁴⁵

Size of the Eco-innovation Market

While the market for environmental goods and services is already very large, eco-innovation presents interesting growth perspectives for an ever greater number of Australian businesses, thanks to a wide variety of niche market opportunities. It is comparable in size to the pharmaceutical and aerospace sectors, and demand is expected to significantly grow in the near future.⁴⁴⁶

In 2006, the global market for environmental goods and services was valued at US\$690 billion, with some analysts expecting it to rise to US\$1.9 trillion by 2020 and it is now recognised that environmental services, in sectors such as tourism or energy production, can deliver both economic and social benefits. Within the environmental industry, services represent the most important component, accounting for 65 per cent of total market value.⁴⁴⁷

Government as an Innovation Incubator

Government support will remain critical to transform national systems of innovation. Policymakers at all tiers of government need to maintain the progress that enabling legislative frameworks and finance mechanisms deliver, particularly if Australia's small and medium-sized enterprises are to play a major role in a transition to a green economy.

There are already examples of business innovations that simultaneously generate business value while delivering economic and social opportunity and enhancing biodiversity and ecosystem services.

Conclusion

The greening of economies, in Australia, across the region and on a global scale, represent a new engine of growth – one that can serve as both a net generator of jobs and a vital strategy for reducing carbon emissions, enhancing energy efficiency, and preventing the loss of biodiversity.

Australian business is developing sustainability technologies and the knowledge to be part of the agenda that can restore the planet and ensure sustainable, developed lifestyles for future generations. Innovation will play a large part in achieving sustainability goals of a green economy, which will provide major opportunities for Australian business today and in the future. We can develop a successful economy, a transformational economy through research and knowledge driven industries, namely the high-value added industries, and therefore achieve higher growth rates.

The key business drivers need to be ones of resilience and adaptability to embrace complexity. Australia is already on the path toward a green economy. The task ahead is to actively explore opportunities for innovation, collaboration, commercial agreement and potential investment. The sustainable enterprise will be the key business vehicle of the 21st century.

444 www.resources.news.com.au/files/2012/12/13/1226536/172570-aus-file-shell-innov-mag.pdf [Accessed 8 May 2013].

445 <http://challenge.ecomagination.com/home> [Accessed 8 May 2013].

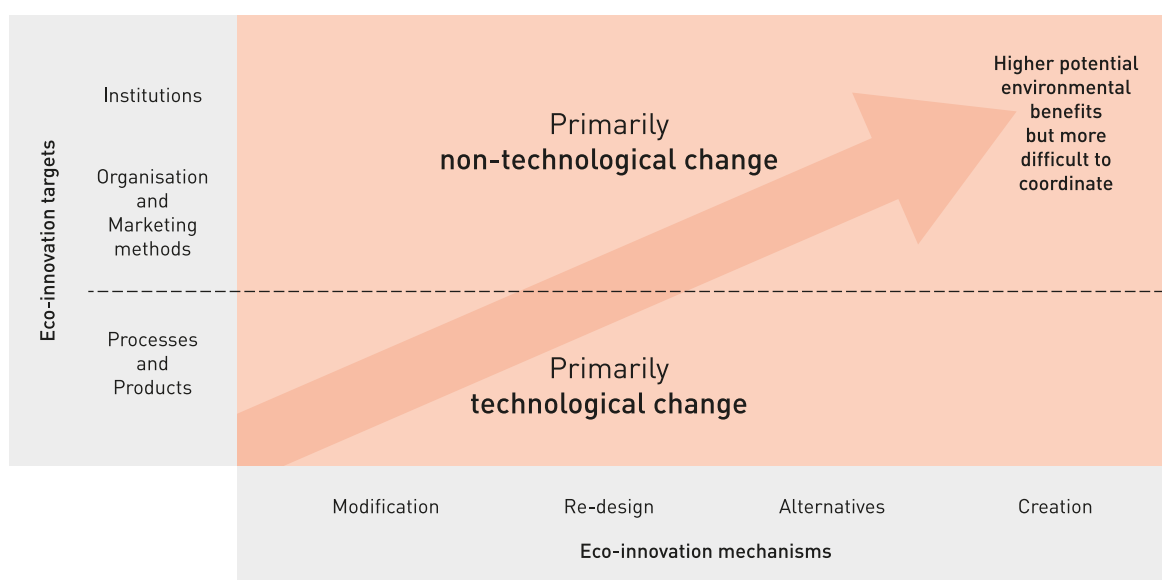
446 http://www.auscleantech.com.au/ACT_Reports.html [Accessed 8 May 2013].

447 UNEP, International Trade Centre (ITC) & International Centre for Trade and Sustainable Development (ICTSD) (2012) *Trade and Environment Briefings: Trade and Green Economy*, ICTSD Programme on Global Economic Policy and Institutions, Policy Brief No. 1, International Centre for Trade and Sustainable Development, Geneva, Switzerland.

Measuring eco-innovation

Innovation, by definition,⁴⁴⁸ can range from the adoption of pre-existing technologies to the development of world-first business models or communities of practice (Figure 5.1). Eco-innovation can in part be measured indirectly from changes in resource efficiency and productivity over time, as well as measuring the proportion of businesses that innovate for environmental reasons.⁴⁴⁹ This is because businesses seeking resource-efficiency through innovation are often unintentional eco-innovators i.e. their primary objective of the innovation was not environmental benefit. Additionally, environmental benefits can be at the firm level, such as process innovation, or at the end-user level through more efficient services. So measures of green growth and eco-innovation must take into account these additional conceptual dimensions to innovation measurement. The OECD defines eco-innovation as *the implementation of new, or significantly improved products (goods or services), processes, marketing methods, organisational structures and institutional arrangements which, with or without intent, lead to environmental improvements compared to relevant alternatives.*⁴⁵⁰

Figure 5.1 A typology of eco-innovation



Source: OECD (2010) *Eco-innovation in Industry: Enabling green growth*, OECD Publishing, p46

Note: Eco-innovation can be understood and analysed according to three axes—targets (the basic focus area of eco-innovation), mechanisms (methods by which the change in the target takes place or is introduced) and impacts (the eco-innovation's effects on the environment).

A profile of Australian eco-innovators

Historically there has been no direct national assessment of the extent or rate of eco-innovation in Australia. This section gives the first complete snapshot of eco-innovation activity in Australia for 2010–11 onwards. The data shows that environmental management activities are being undertaken by 38% of all Australian businesses with only a smaller fraction reducing their environmental footprint through innovation and an even smaller fraction of businesses doing so deliberately (Chart 5.5). The percentage of all Australian businesses that reduced their environmental footprint through innovation was 10.1% in 2011–12 (Chart 5.5). For small businesses (0–19 employees) the percentage was 9.5% increasing to 22.3% and 46.0% for medium (20–199 employees) and large (200+ employees) businesses, respectively. There is considerable variation between sectors on these numbers. The level of eco-innovation in manufacturing businesses was double the national average at 20.3%. Australia appears to also rank relatively poorly compared to other OECD countries (national averages vary 10–75%) on environmentally related innovation (these countries range between from 10% to 75%).⁴⁵¹ This data reinforces earlier conclusions on trends in resource productivity. The data suggests that Australia is behind many OECD countries in terms of timely progress on eco-innovation and leadership. Further refinement of data collection is needed to improve these country comparisons.

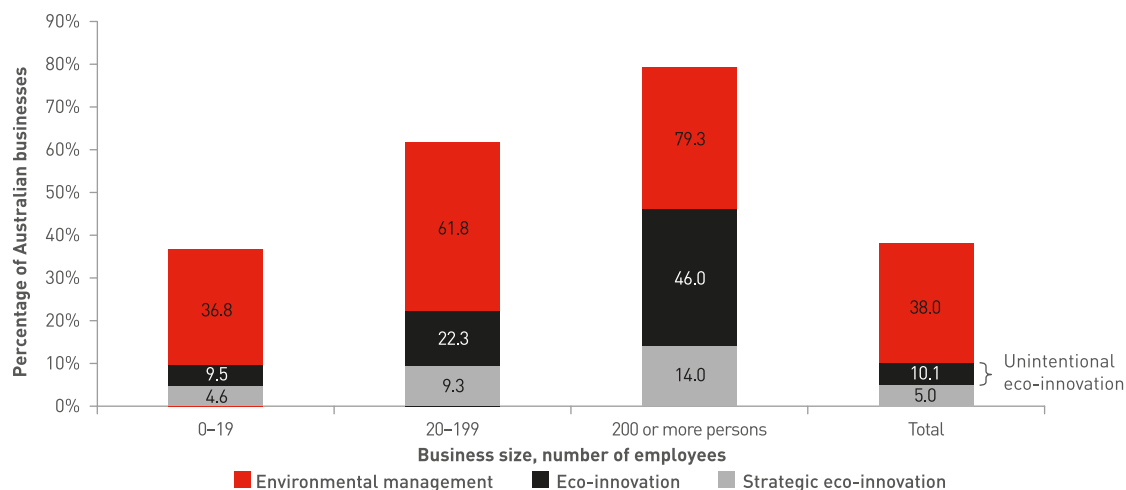
⁴⁴⁸ See Introduction to this report.

⁴⁴⁹ OECD (2009) *Sustainable Manufacturing and Eco-innovation: Framework, Practices and Measurement*, Synthesis Report, OECD Publishing.

⁴⁵⁰ *Ibid.*

⁴⁵¹ OECD (2011) *Towards Green Growth: Monitoring Progress*, OECD Publishing, p.114.

Chart 5.5 The level of environmental management, broader eco-innovation and strategic eco-innovation in Australia, 2010–2012



Sources: ABS (2013) *Energy Use, Electricity Generation and Environmental Management, Australia, 2011–12*. cat. no. 4660.0; ABS (2012) *Innovation in Australian Business 2010–11*, cat. no. 8158.0

Approximately half of Australia’s eco-innovators appear to be reducing their environmental footprint unintentionally through innovation projects designed to improve their productivity or other objectives (Chart 5.5; see also above section on definitions). The average proportion of *strategic eco-innovators*⁴⁵² was 5.0% across all business sizes and sectors in 2010–11 and this has not changed since 2006–07 (Table 5.1; Chart 5.5). Like the broader level of eco-innovation there is a strong size effect, with SMEs ranging from 4.6% to 9.3% and large firms at around 14.0%. Although the overall proportion of SME strategic eco-innovation is low compared to large businesses, the ratio of ‘strategic’ to ‘unintentional’ eco-innovation is much higher in SMEs (Chart 5.5).

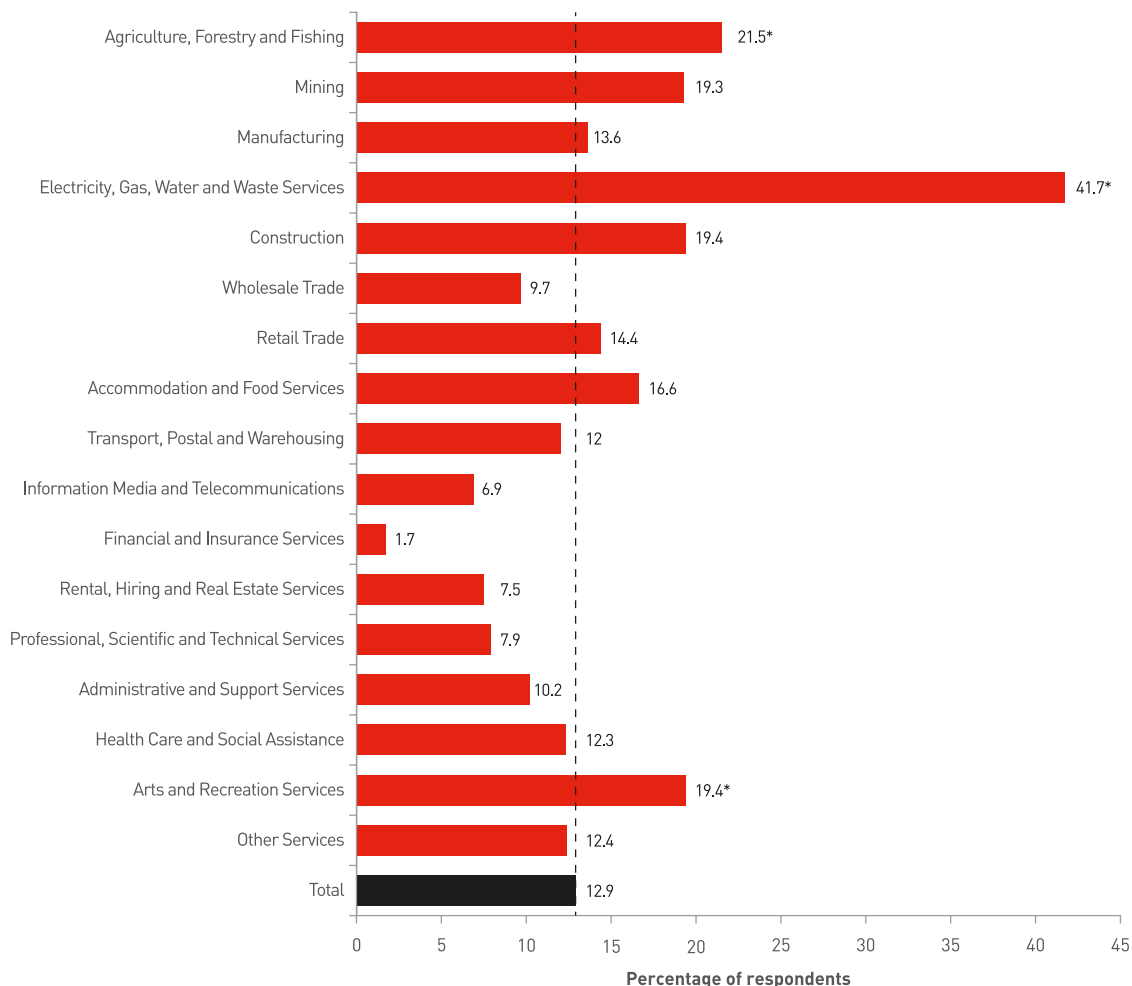
The levels of strategic eco-innovation also vary by sector, with the more resource-intensive industries being more likely to deliberately innovate to reduce environmental impacts (Chart 5.6). The construction, mining and electricity, gas, water and waste services sectors of the Australian economy have a high proportion of strategic eco-innovation (Chart 5.6). This result is not surprising and supports the global findings of the recent *Innovation Bottom Line* report.⁴⁵³ Other sectors that are above the Australian average include agriculture, forestry and fishing, retail trade, manufacturing, accommodation and food services and arts and recreation services. Financial and insurance services are well below average—at 1.7% (Chart 5.6). Placed in an international context, however, all Australian industry sectors appear to perform poorly on eco-innovation. A rough⁴⁵⁴ comparison between Australian and equivalent European (EU) sectors suggests that Australia is at or below average in every sector.

452 The ABS Business Characteristics Survey measures the proportion of innovation-active businesses that reported ‘reduce environmental impacts’ as a reason for innovating. These businesses can be classified as strategic ‘eco-innovators’ for the purposes of this report. This categorisation of innovation-active firms does not exclude innovation for other reasons, as firms can select more than one reason for innovating. ‘Other innovators’ are therefore innovation-active businesses that are not driven to innovate in order to reduce environmental impacts.

453 Kiron D, Kruschwitz N, Haanaes K, Reeves M & Goh E (2013) *The Innovation Bottom Line, Research Report Winter 2013*, MIT Sloan Management Review and The Boston Consulting Group, Cambridge.

454 There are considerable methodological differences between the EU Community Innovation Survey 2008 Eco-innovation module and ABS official data. This comparison is an approximation only. EU data includes responses to a range of environmental benefits. Data available on request.

Chart 5.6 Proportion of innovation-active businesses that are innovating to reduce environmental impacts, by industry, 2010–11



Source: ABS (2012) *Innovation in Australian Business 2010–11*, cat. no. 8158.0

Note: Asterisks indicate relative standard errors of 10–25%.

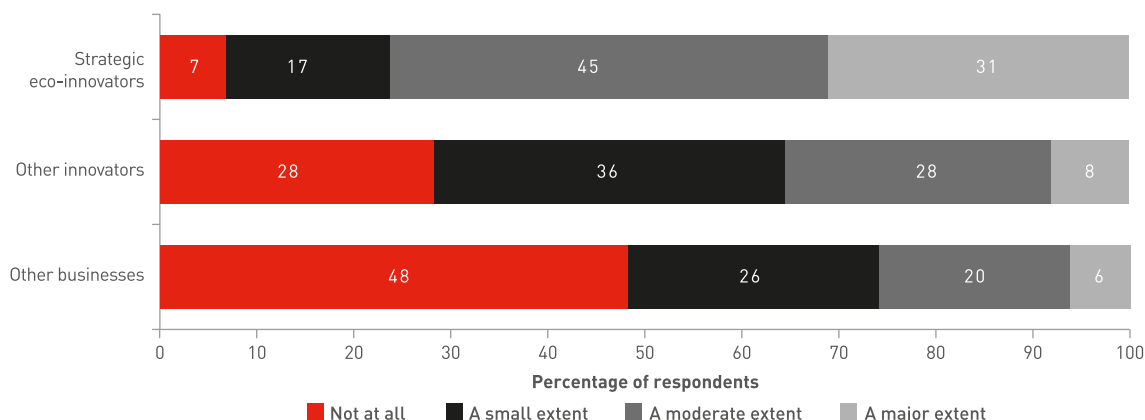
The following data suggests that strategic eco-innovators are in many respects high performing firms that tend to be more aware of their environmental impacts. Strategic eco-innovation appears to be synonymous with high-quality business. This conclusion fits with other research showing that green entrepreneurs are highly ambitious and their ventures have highly capable teams.⁴⁵⁵

One of the key practices of these sustainability-driven innovators is their efforts to measure and track sustainability goals and performance.⁴⁵⁶ Australian strategic eco-innovators are almost twice as likely as non-innovators to focus on environmental measures when assessing their performance (Chart 5.7). Similar to the proportion of innovation-active businesses, the extent to which Australian businesses focus on environmental measures when assessing their performance has remained relatively stable over the last four years. By contrast, the proportion of businesses undertaking environmental management activities has increased since 2008–09.

455 Gordon SR, Davidsson P & Senyard J (2013) *What it means to be green: An examination of early stage environmental and sustainability focused firms*. Business Creation in Australia Report Series 4, Queensland University of Technology, Brisbane. Research commissioned by DIICCSRTE.

456 Kiron D, Kruschwitz N, Haanaes K, Reeves M & Goh E (2013) *The Innovation Bottom Line, Research Report Winter 2013*, MIT Sloan Management Review and The Boston Consulting Group, Cambridge.

Chart 5.7 The extent to which business focused on environmental measures when assessing performance, by innovation status, 2010–11



Source: DIISRTE Custom data request from the ABS (2012) *Innovation in Australian Business 2010–11*, cat. no. 8158.0

Note: Environmental measures include recycling programs, adherence to environmental regulations, sustainability considerations and carbon footprint analysis.

Investment in eco-innovation

Research and Development (R&D) plays a crucial role in generating disruptive and radical innovations, fuel for a green growth economy. Significant investments in environmental R&D show that businesses have integrated sustainability into their core strategy, serving as a strong indicator for investors betting on increasing consumer demand for green products. Additionally, this data helps identify innovative companies who are ahead of the curve in responding to heightening environmental risks and regulations.⁴⁵⁷ Unfortunately only limited trend data is available on Business Expenditure on Research and Development (BERD) data classified by socio-economic objective.⁴⁵⁸ In 2010–11 Australian BERD spending on the ‘environment’ was \$243.9 million or 1.4% of total BERD (Chart 5.8). Major areas of R&D focus included land and water management and rehabilitation of degraded environments. Since 2007–08, elements of BERD directed at environmentally sustainable economic development have also been identified. In 2010–11 this was \$401.4 million across all industry sectors, bringing total R&D investment in environmental sustainability to \$645.3 million or 3.6% of total BERD. The largest contributing sectors were energy, construction, mining and manufacturing.

Annual growth rates for environmental R&D have been significantly higher in the last four years than other R&D investments. Public investment in environmental R&D is high by international standards and environmental technology patenting is improving, with Australia’s ranking at moderate to high (See Table 5.1). The Australian Government allocated \$313 million or 3.6% of its R&D budget to the environment⁴⁵⁹ in 2013–14. This represents an 80% increase since 2004–05 (3.3%). As of 2010, Australia ranked 2nd in the OECD⁴⁶⁰ in public spending on environmental R&D (Table 5.1); however, this data does not capture the recent sharp decline in Australian Government investment—down from 5.2% in 2012–13.

Recent experimental work suggests that the impact of Australia’s publicly funded environmental research is high.⁴⁶¹ The latest available data shows that public R&D expenditure on the environment was around \$1.4 billion, not including aspects of public investments in economic development that may be oriented towards environmental sustainability.⁴⁶² It is reassuring that eco-innovators are much more likely to collaborate and source ideas for innovation from public research institutions (see below). Public sector investments in environmental sustainability may therefore be compensating for Australia’s relatively low business expenditure. This may explain in part Australia’s relatively high performance in environmental technology development (see data below).

⁴⁵⁷ Henderson H, Sanquiche R & Nash T (2013) *Green Transition Inflection Point: Green Transition Scoreboard® 2013 Report*, Ethical Markets Media, February 2013.

⁴⁵⁸ The Australian Standard Research Classification (ASRC) used to collect and compile socio-economic objective data was revised in 1998 and again in 2008, when it became the Australian and New Zealand Standard Research Classification (ANZSRC). Implementation of the updated Classification in the 1999–2000 and 2007–08 reference periods, respectively, represent breaks in this data series.

⁴⁵⁹ Note that if you include Energy and Agriculture, which are often environment-related, the percentage is 17.4%.

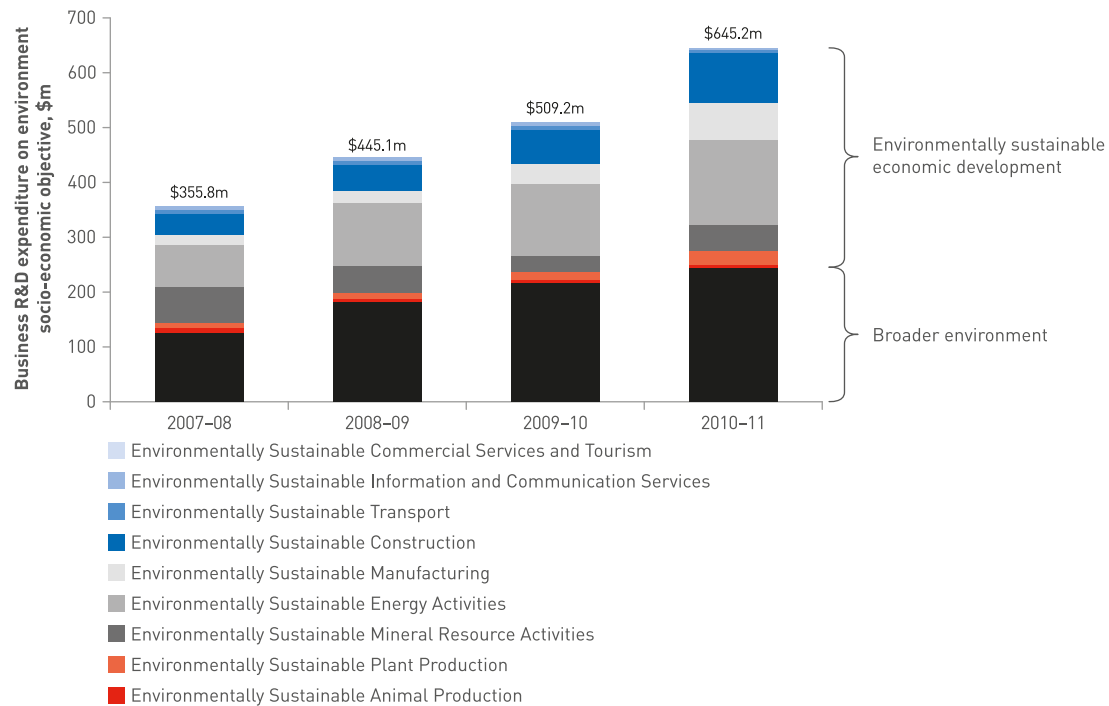
⁴⁶⁰ Behind Estonia at 10.6%. Note that New Zealand and Canada are often higher than Australia but had not provided data to the OECD for the latest year.

⁴⁶¹ <http://www.atn.edu.au/eia/index.htm> [Accessed 1 July 2013].

⁴⁶² Australian Government (2012) *Australian Innovation System Report – 2012*, DIISRTE, Canberra, p.24.

Reviewing the environmental management activities undertaken by Australian businesses⁴⁶³ the most popular activities appear to be improvements in 'business as usual' processes. This data agrees with our understanding that most Australian innovators are adopters and modifiers rather than world-first innovators.⁴⁶⁴ It also suggests that if Australia is to lead a green growth transition then policies and business cultures need to foster more systemic or radical innovations. Continued and growing investments in environmental research, design and engineering are required.

Chart 5.8 Business expenditure on R&D devoted to the environment and environmentally sustainable economic development, by sector, 2007–08 to 2010–11



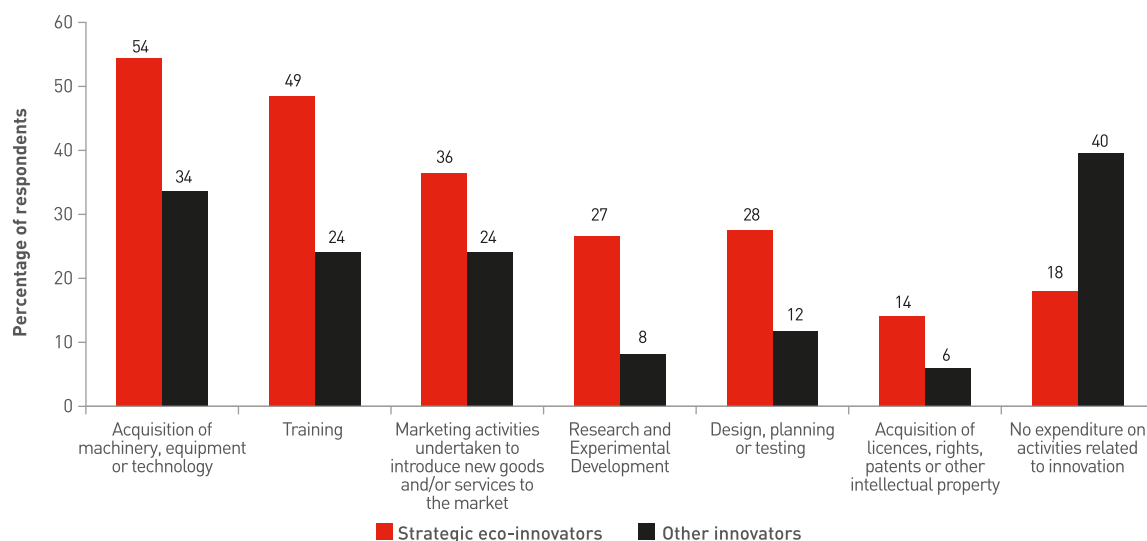
Source: ABS (2012) *Research and Experimental Development, Businesses, Australia, 2010–11*, cat. no. 8104.0.

Strategic eco-innovators are 60% to 300% more likely than other innovators to invest in a range of innovation activities, such as the acquisition of technology and training. Eco-innovators are twice as likely to spend money on innovation. The overall patterns of investment by strategic eco-innovators seem to emphasise R&D and de-emphasise marketing and acquisition of machinery, equipment and technology (Chart 5.9). The least likely investment by strategic eco-innovators appears to be acquiring R&D from other businesses (data not shown).

463 ABS (2010) *Energy, Water and Environment Management, 2008–09*, cat. no. 4660.0; ABS (2013) *Energy Use, Electricity Generation and Environmental Management, Australia, 2011–12*, cat. no. 4660.0

464 Australian Government (2011) *Australian Innovation System Report – 2011*, DIISR, Canberra, pp.22–23.

Chart 5.9 Types of expenditure for innovation purposes, by innovation status, 2010–11



Source: DIISRTE Custom data request from the ABS (2012) *Innovation in Australian Business 2010–11*, cat. no. 8158.0

Performance characteristics of strategic eco-innovators

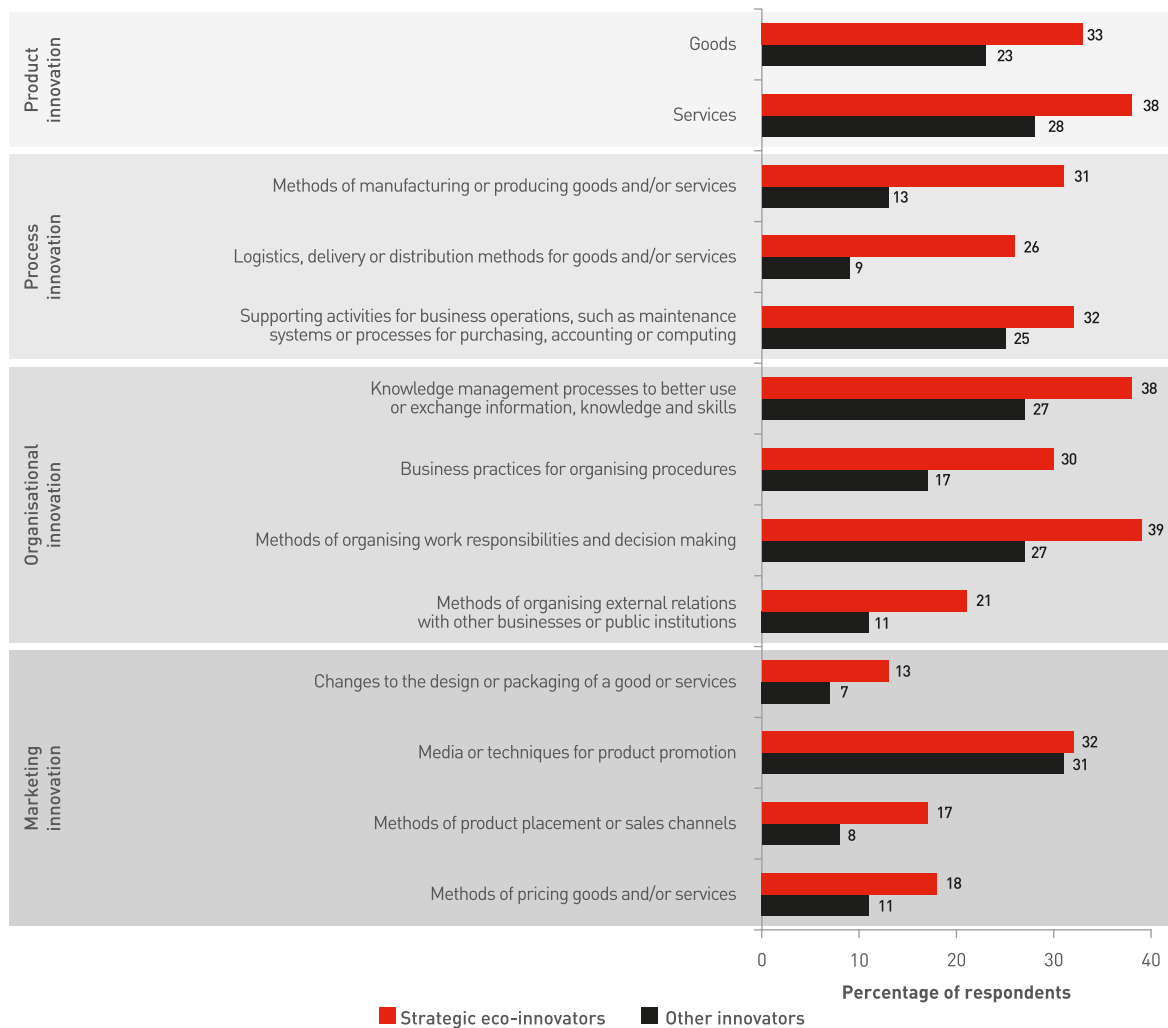
Given the higher likelihood of expenditure on innovation, it is no surprise that eco-innovators are more likely to report all types of innovation (Chart 5.10). The more stark differences between strategic eco-innovators and other innovators are in production process, logistics, design or packaging innovation. The need for new forms of supply chain co-operation around complete product life cycle management, such as industrial symbiosis, is evident in the higher likelihood of organisational innovation in external relations and logistics and supply chain innovation. Interestingly, the one type of innovation where strategic eco-innovators are no different from other innovators is in new forms of product promotion (see also Chart 5.10).

Innovation is often thought of as technology development, however, more non-technological innovation is increasingly required for a transition to a green economy. Business model innovation is increasingly argued to bridge the gap between radical or systemic eco-innovation and business strategy and performance.⁴⁶⁵ Compared to other countries, Australian and New Zealand-based companies are leading the way in integrating sustainability goals into their business models, particularly resource-intensive businesses.⁴⁶⁶ The more elements of their business model they changed the more likely these businesses were to report profit from their sustainability activities, particularly if these business model innovations were around value chain processes and target segments.

465 OECD (2012) Green Business models for systematic eco-innovations, DSTI/IND (2012)23; Boons F, Montalvo C, Quist J & Wagner M (2013) Sustainable innovation, business models and economic performance: An overview, *Journal of Cleaner Production*, **45**, 1–8.

466 Kiron D, Kruschwitz N, Haanaes K, Reeves M & Goh E (2013) *The Innovation Bottom Line, Research Report Winter 2013*, MIT Sloan Management Review and The Boston Consulting Group, Cambridge.

Chart 5.10 Types of innovation contrasted between strategic eco-innovators and other innovators, 2010–11



Source: DIISRTE Custom data request from the ABS (2012) *Innovation in Australian Business 2010–11*, cat. no. 8158.0

A considerable and growing body of research shows there is a strong relationship between eco-innovation, environmental management and industry performance or competitiveness.⁴⁶⁷ Given the higher likelihood of measurement of environmental performance, investment and almost all forms of innovation, it would be expected that Australian eco-innovators tend to perform considerably better than other innovation-active businesses and considerably better than non-innovation-active businesses. Chart 5.11 confirms a significant productivity growth advantage. Compared with innovative businesses that don't deliberately pursue environmental benefits, strategic eco-innovators are:

- 30% more likely to increase productivity over the previous year.
- 40% more likely to increase the number of export markets targeted.
- 68% more likely to increase training for employees.
- 41% more likely to increase social contributions (Chart 5.11).

Other performance measures don't appear to show any differences between strategic eco-innovators and other innovators. The data suggests that the performance benefits reported by strategic eco-innovators are higher in SMEs than in large firms, with the exception of the number of export markets targeted (data not shown; see Chapter 2 for discussion of export orientation and firm size). Further analysis and improved data collection are required to adequately differentiate size and industry effects. This result is similar to the collaboration results described in Chapter 2 which suggests that strategic *eco-innovators*

⁴⁶⁷ Brunnermeier SB & Cohen MA (2003) Determinants of environmental innovation in US manufacturing industries, *Journal of Environmental Economics and Management*, **45**, 278–293; Eiadata Y, Kelly A, Roche F & Eyadat H (2008) Green and competitive? An empirical test of the mediating role of environmental innovation strategy, *Journal of World Business*, **43**, 131–145.

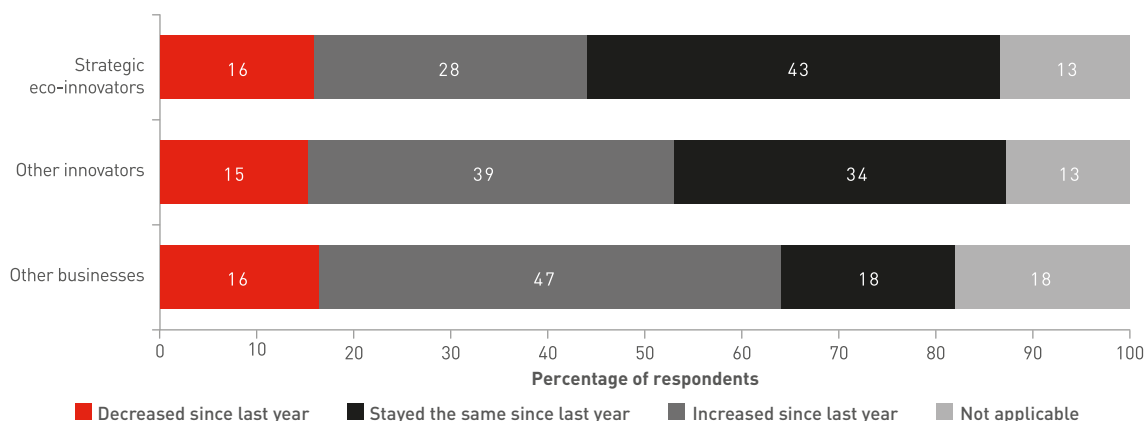
generally represent a cohort of high performing Australian businesses that take their environmental impacts seriously. Limited analysis of business size classes indicates that there are more medium (20–199 employees) and large-sized (200+ employees) businesses and fewer micro-sized (0–4 employees) businesses in the eco-innovator category. This may partly explain the innovation performance edge (there is a strong size effect) in eco-innovators, but doesn't explain the other improved performance characteristics, such as productivity (which is most strongly expressed in SMEs).⁴⁶⁸

Strategic eco-innovators are more likely to collaborate and have extensive knowledge networks

Innovation is a highly interactive, multidisciplinary process that increasingly involves collaboration and partnerships between a growing and diverse network of organisations and individuals.⁴⁶⁹ Eco-innovation is no exception, with quantitative and qualitative data from around the world⁴⁷⁰ and from Australia⁴⁷¹ (Chart 5.11) showing that eco-innovation activity is strongly linked with the development of knowledge networks and collaboration, particularly industry research collaboration.⁴⁷²

Strategic eco-innovators are twice as likely to collaborate on innovation (40%) than other innovators (21%) and are much more likely to collaborate with overseas organisations.⁴⁷³ Official data also suggests that strategic eco-innovators are less likely to be adopters or modifiers than other innovators. A higher proportion of strategic eco-innovators are introducing innovations developed in collaboration with others (39%) compared with other innovators (29%). Conversely, the proportion of strategic eco-innovators that adopt or modify the innovations of others (11%) is lower than other innovators (18%).

Chart 5.11 Changes in business productivity performance contrasted between strategic eco-innovators, other innovators and non-innovation-active businesses, 2010–11



Source: DIISRTE Custom data request from the ABS (2012) *Innovation in Australian Business 2010–11*, cat. no. 8158.0

Note: 'Strategic eco-innovators' are innovation-active businesses who reported reducing environmental impact as a reason for innovating.

468 See size discussion in Australian Government (2012) *Australian Innovation System Report – 2012*, DIISRTE, Canberra, pp.55–57.

469 Refer to literature and data cited in previous *Australian Innovation System reports—2012* (pp.64–72) and 2011 (pp.80–90), www.innovation.gov.au/aisreports.

470 Wagner M (2007) On the relationship between environmental management, environmental innovation and patenting: Evidence from German manufacturing firms. *Research Policy*, **36**(10), 1587–1602; Carrillo-Hermosilla J, del Rio P & Konnola (2010) Diversity of eco-innovations: Reflections from selected case studies, *Journal of Cleaner Production*, **18**(10–11), 1073–1083; OECD (2012) *Green Business models for systematic eco-innovations*, DSTI/IND (2012)23; Triguero A, Moreno-Mondejar L & Davia MA (2013) Drivers of different types of eco-innovation in European SMEs, *Ecological Economics*, **92**, 25–33. Kiron D, Kruschwitz N, Haanaes K, Reeves M & Goh E (2013) *The Innovation Bottom Line, Research Report Winter 2013*, MIT Sloan Management Review and The Boston Consulting Group, Cambridge.

471 Chong J, Asker S, O'Rourke A and White S (2012) *Green Chrysalis—Small and medium-sized enterprises: Innovation and transformation towards Australia's low-carbon economy*. Report prepared for the Australian Business Foundation by the Institute for Sustainable Futures, University of Technology, Sydney; Gordon SR, Davidsson P & Senyard J (2013) *What it means to be green: An examination of early stage environmental and sustainability focused firms*. Business Creation in Australia Report Series 4, Queensland University of Technology, Brisbane. Research commissioned by DIICCSRTE.

472 The applied research being undertaken by Curtin University's Sustainable Engineering Group is an excellent example of how collaboration is a fundamental requirement for delivering both industrial resource efficiency and social improvement. <http://cleanerproduction.curtin.edu.au/research/ecology.cfm> [Accessed 8 May 2013].

473 DIISRTE Custom data request from the ABS (2012) *Innovation in Australian Business 2010–11*, cat. no. 8158.0.

Strategic eco-innovators are much more likely to source ideas or information for innovation from a range of sources compared with other innovators (Chart 5.12). Ideas from within the firm or business group still remains the most likely source for eco-innovation at 71%. Strategic eco-innovators are also two to five times more likely to source ideas and information on innovation from research organisations compared with other innovators. This data suggests that strategic eco-innovators in Australia have more diverse external networks, more emphasis on industry research collaboration and, consequently, a much higher absorptive capacity and greater potential to generate systemic or radical innovations than other innovators (See also Chapter 2 discussion).

Collaboration is a fundamental aspect of eco-innovation given that businesses have to think outside the organisation to reduce their environmental impacts. On average, 60% of a business's environmental costs come from their supply chain.⁴⁷⁴ This has direct implications for the role of cooperation and collaboration between businesses in addressing environmental issues and suggests why eco-innovators are by nature more collaborative. At a higher level, minimising resource use across supply chains or minimising waste or emissions in an entire resource-product-waste cycle requires considerable cooperation between all actors in an innovation system. This is particularly important where eco-innovations are radical or systemic and require innovation system-level changes to such framework conditions as culture, regulation and infrastructure.⁴⁷⁵

Eco-innovation and skills

Eco-innovation will drive the creation of new sectors of the economy and the fundamental re-engineering or decline of existing sectors. This structural transition will not only create high demand for skills that are oriented towards sustainability, but also require flexible labour market policies that minimise skill bottlenecks and avoid structural unemployment.⁴⁷⁶

A number of recent Australian reports have predicted an increasing need for new skills for the green economy and training (to supply those skills) that is driven by stronger consumer preferences and government legislation.⁴⁷⁷ Data on online green collar job advertisements support this. It shows strong short to medium term growth in the green jobs market relative to the national employment market.⁴⁷⁸ Strategic eco-innovators are consistently more likely to report higher use of skills for core business activities across almost all skill categories compared with other innovators and non-innovators (Chart 5.13a). The most notable differences are in science, research and engineering skills (approximately twice as likely in strategic eco-innovators). This data may reflect demand from strategic eco-innovators that generally have much more experienced, better educated leaders and teams.⁴⁷⁹ In 2009, 38% of the Australian businesses surveyed expected increased environmental/sustainability skills needs in the next three to five years.⁴⁸⁰ Types of skills identified by these businesses included understanding compliance issues, environmental awareness skills, specialist environmental skills such as environmental engineering and knowledge about green products and processes.⁴⁸¹

474 This is much less extreme in the resources, chemical and utilities sectors than it is in many service sectors (closer to 80%); Makower J (2013) *State of green business 2013*, GreenBiz Group & Trucost, Oakland, California.

475 Carrillo-Hermosilla J, del Rio P & Konnola (2010) Diversity of eco-innovations: Reflections from selected case studies, *Journal of Cleaner Production*, **18**, 1073–1083.

476 OECD (2011) *Towards Green Growth*, OECD Publishing.

477 Australian Government (2010) *Skills for a sustainable future: Analysis of an employer survey conducted in November/December 2009*, DEEWR Economic strategy group and climate change and green skills taskforce, Canberra; Australian Council of Trade Unions (ACTU) & Australian Conservation Foundation (2010) *Creating jobs – Cutting pollution: The roadmap for a cleaner, stronger economy*, ACTU & Australian Conservation Foundation, Melbourne; CSIRO (2008) *Growing the green collar economy: Skills and labour challenges in reducing our greenhouse emissions and national environmental footprint*, Report to the Dusseldorp Skills Forum, CSIRO, Canberra.

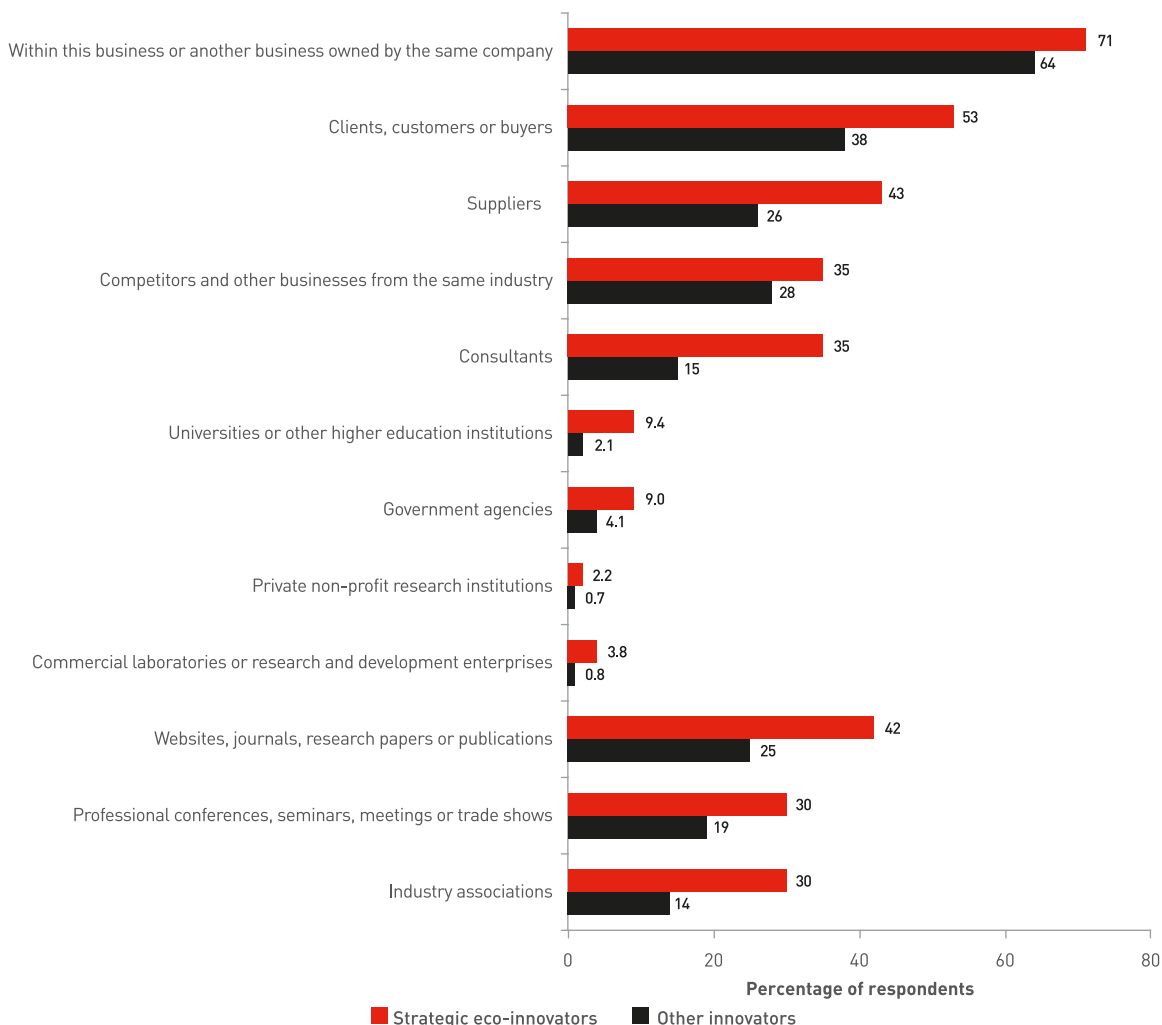
478 <http://greencollartalent.com.au/jobindex> [Accessed at 30 May 2013].

479 Gordon SR, Davidsson P & Senyard J (2013) *What it means to be green: An examination of early stage environmental and sustainability focused firms*. Business Creation in Australia Report Series 4, Queensland University of Technology, Brisbane. Research commissioned by DIICCSRTE.

480 Australian Government (2010) *Skills for a sustainable future: Analysis of an employer survey conducted in November/December 2009*, DEEWR Economic strategy group and climate change and green skills taskforce, Canberra.

481 *Ibid.*

Chart 5.12 Sources of ideas or information for innovation by eco-innovation status, 2010–11



Source: DIISRTE Custom data request from the ABS (2012) Innovation in Australian Business 2010–11, cat. no. 8158.0

Note: ‘Strategic eco-innovators’ are innovation-active businesses who reported reducing environmental impact as a reason for innovating.

Official data shows that strategic eco-innovators experience elevated skill shortages or deficiencies across the range of skills for undertaking core business, most particularly in trades at 17% (Chart 5.13b). Engineering, IT support, trades and project management skill groups are notably higher than other innovators. This data supports earlier findings that businesses demand trained environmental specialists such as site managers, environmental auditors, engineers and designers.⁴⁸² Although strategic eco-innovators are no more likely to report lack of skills as an overall barrier to innovation compared to other innovators, it is clear that strategic eco-innovators are more likely to report skills shortages or deficiencies within the labour market (46% higher compared with other innovators).

⁴⁸² *Ibid.*

Many SME eco-innovators emphasise ‘learning by doing’ rather than formal knowledge acquisition.⁴⁸³ Difficulties in sourcing this more tacit knowledge through the labour market may act as a greater barrier to eco-innovation in Australia. Businesses tend to use inhouse or private providers or conferences and seminars for building environmental and sustainability skills, particularly in environmental awareness and compliance.⁴⁸⁴ As policies such as the Council of Australian Government’s green skills agreement⁴⁸⁵ take effect, labour market shortages in the more technical green skills may ease. This data may also explain a greater emphasis on collaboration among eco-innovators who value the knowledge obtained by other ‘doers’ more highly. This education of suppliers and customers is where the multiplier effect from eco-innovation can come and policies that facilitate learning through networking and communities of practice should not be underestimated.⁴⁸⁶

Drivers of and barriers to eco-innovation in Australia

OECD research shows that there is no quick and easy policy solution to the challenge of creating green growth. A well-coordinated, complementary policy mix is required at all points of the innovation cycle⁴⁸⁷ and in all sectors of the economy. Government regulation is particularly important in encouraging firms to reduce pollution, avoid hazardous substances, and increase recyclability of products. Cost savings are an important motivation for reducing energy and material use, highlighting the role of energy and raw material prices, as well as taxation, as drivers of eco-innovation. Customer requirements are another important source of eco-innovations, particularly with regard to products with improved environmental performance and process innovations that increase material efficiency and reduce energy consumption, waste and the use of dangerous substances.⁴⁸⁸

Effective pricing and regulation of finite resources, pollution and environmental damage will generally encourage incremental innovation if the market signal is clear and stable.⁴⁸⁹ They will also enhance efficiency in the allocation of resources to new environmental markets, thereby lowering the overall costs of a transition to a green economy.⁴⁹⁰ Although effective pricing tends to increase resource efficiency it may also lead to increased consumption of that resource. Neither will it help overcome all technical risks of innovation if the prices are kept low. Complementary policies—such as environmental research and education—that encourage a more socially optimal level of radical or systemic innovation are therefore required.⁴⁹¹

The evidence from Australia and elsewhere suggests that businesses don’t just engage in sustainable practice for regulatory compliance reasons. There are ethical considerations, costs reductions or quality premiums and consumer, employee and investor preferences to manage.⁴⁹² Increasingly business environmental sustainability considerations are linked to reducing supply chain risk and ensuring business continuity during disruptions, as well as the right to operate in resource-stressed areas, reliable and cost-efficient resources, and brand value and reputation.⁴⁹³

Business eco-innovators are by definition trying to capture a win-win in economic and environmental terms. More important, businesses appear to be generally motivated to undertake eco-innovation to satisfy customer and societal requirements, but the level of investment is driven by other factors like cost savings, organisational capabilities, knowledge networks and environmental regulation.⁴⁹⁴ Research from around

483 Chong J, Asker S, O’Rourke A & White S (2012) *Green Chrysalis—Small and medium-sized enterprises: Innovation and transformation towards Australia’s low-carbon economy*, Report prepared for the Australian Business Foundation by the Institute for Sustainable Futures, University of Technology, Sydney.

484 *Ibid.*

485 www.innovation.gov.au/GreenSkillsAgreement [Accessed at 30 May 2013].

486 Chong J, Asker S, O’Rourke A & White S (2012) *Green Chrysalis—Small and medium-sized enterprises: Innovation and transformation towards Australia’s low-carbon economy*, Report prepared for the Australian Business Foundation by the Institute for Sustainable Futures, University of Technology, Sydney.

487 OECD (2004) *The economic impact of ICT: Measurement, evidence and implications*, OECD Publishing.

488 Horbach J, Rammer C & Rennings K (2012) Determinants of eco-innovations by type of environmental impact: The role of regulatory push/pull, technology push and market pull, *Ecological Economics* **78**, 112–122.

489 ClimateWorks Australia (2013) *Tracking Australia’s progress towards a low carbon economy*, ClimateWorks Australia, Melbourne.

490 Triebswetter U & Wackerbauer J (2008) Integrated environmental product innovation in the region of Munich and its impact on company competitiveness, *Journal of Cleaner Production*, **16**, 1484–1493.

491 OECD (2011) *Towards Green Growth*, OECD Publishing.

492 Chong J, Asker S, O’Rourke A & White S (2012) *Green Chrysalis—Small and medium-sized enterprises: Innovation and transformation towards Australia’s low-carbon economy*, Report prepared for the Australian Business Foundation by the Institute for Sustainable Futures, University of Technology, Sydney *Ibid*; Gordon SR, Davidsson P & Senyard J (2013) *What it means to be green: An examination of early stage environmental and sustainability focused firms*. Business Creation in Australia Report Series 4, Queensland University of Technology, Brisbane. Research commissioned by DIICCSRTE; Australian Government (2010) *Skills for a sustainable future: Analysis of an employer survey conducted in November/December 2009*, DEEWR Economic strategy group and climate change and green skills taskforce, Canberra.

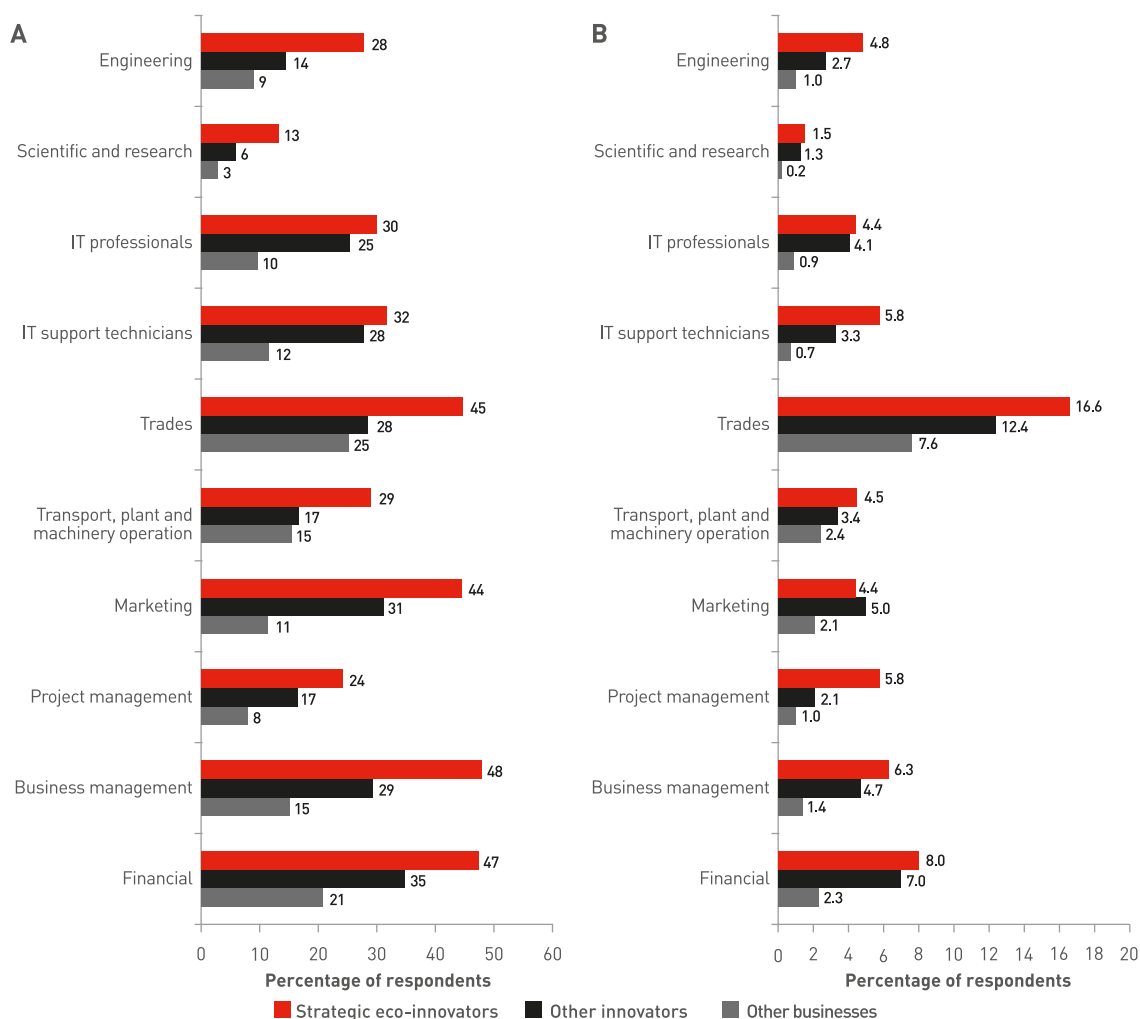
493 Makower J (2013) *State of green business 2013*, GreenBiz Group & Trucost, Oakland, California.

494 Wagner M (2007) On the relationship between environmental management, environmental innovation and patenting: Evidence from German manufacturing firms. *Research Policy*, **36**(10), 1587–1602; Kesidou E & Demirel P (2012) On the drivers of eco-innovations: Empirical evidence from the UK, *Research Policy*, **41**(5), 862–870.

the world and in Australia shows that drivers of eco-innovation also vary with the type of innovation and that motivations vary significantly with business size.⁴⁹⁵

- Market share is a positive influence on product and organisational eco-innovation.
- Production costs, driven by resource prices and environmental taxes, are a significant driver of process eco-innovation.
- Government regulation is a significant driver for reducing pollution through process innovation and by increasing recyclability of products.⁴⁹⁶

Chart 5.13 Skills used (panel A) and skill shortages or deficiencies (panel B) in undertaking core business activities, by innovation status, 2010–11



Source: DIISRTE Custom data request from the ABS (2012) *Innovation in Australian Business 2010*, cat. no. 8158.0

495 Santolaria M, Olver-Sola J, Gasol CM, Morales-Pinzon T & Rieradevall J (2011) Eco-design in innovation driven companies: Perception, predictions and the main drivers of integration. The Spanish example. *Journal of Cleaner Production*, 19(12), 1315–1323; ABS (2010) Energy, Water and Environment Management, 2008–09, cat. no. 4660.0.

496 Horbach J, Rammer C & Rennings K (2012) Determinants of eco-innovations by type of environmental impact: The role of regulatory push/pull, technology push and market pull, *Ecological Economics*, 78, 112–122; Triguero A, Moreno-Mondejar L & Davia MA (2013) Drivers of different types of eco-innovation in European SMEs, *Ecological Economics*, 92, 25–33.

Quantitative evidence shows that, just like other innovators, strategic eco-innovators are most highly motivated by profit to engage in innovation. Compared with other innovators, strategic eco-innovators are also:

- four times more likely to report government regulations, standards and working conditions as a driver of innovation.
- almost three times more likely to report *increasing the capacity of product or service provision and increasing export opportunities* as a driver of innovation.
- around twice as likely to report *improving the quality of goods and services, increasing the efficiency of production and competitive pricing of products* as a driver of innovation.⁴⁹⁷

Massive challenges exist in overcoming policy, market and institutional failures in the transition to a green growth economy. The most formidable barriers to eco-innovation are a lack of accurately priced environmental resources, technological or cultural lock-in and high transaction costs that resist new, more sustainable patterns of economic development, despite the rising costs associated with increasing environmental degradation. Vested interests reinforce this resistance.⁴⁹⁸ All individuals and organisations must therefore participate in a transition to green growth if Australia is to avoid a fall in the standard of living of future generations.

Like other innovators (62%), a high proportion of strategic eco-innovators (70%) experience one or more barriers to innovation (Chart 5.14). Lack of access to additional funds is a common and high barrier for all types of innovators. Unlike other innovators, however, strategic eco-innovators are 67% more likely to report cost of development or introduction/implementation of innovations as a barrier to innovation (Chart 5.14). Interestingly for strategic eco-innovators government regulation appears to be a net driver of innovation in contrast to other innovators.⁴⁹⁹ Potential barriers to reducing energy consumption or improving energy efficiency reported by Australian businesses in 2008–09 show similar barriers of cost and expertise.⁵⁰⁰ This data generally fits with the results of a study of eco-innovation in Australian SMEs by the Institute of Sustainable Futures and the Australian Business Foundation.⁵⁰¹ This study found that the above challenges can be compounded by policy uncertainty, the difficulty in accurately measuring change and the knowledge-intensive nature of eco-innovation.

Australia's clean technology market

Clean technology or 'cleantech'⁵⁰² is a sub-sector of the economy with a particular focus on renewable and low carbon energy, energy efficiency and management, water efficiency and management, waste management and recycling and environmental assessment, monitoring or remediation. This list of activities is indicative only, as there is no internationally recognised list of cleantech activities. Global investment in sustainable business activity is growing (see introduction to this chapter). The 2012 total global investment in clean energy alone was recorded at US\$269 billion. Growth of the international clean tech sector is being supported by strong growth of the sector in Japan, Mexico and emerging nations like China and South Africa, but offset by the growth slowdown in Europe and the US.⁵⁰³ A recent estimate suggests that the Australian cleantech sector has revenue of \$29 billion a year and employs 53,000 people, making it larger than Australia's automotive manufacturing industry by employment. By revenue, it is estimated to be one quarter the size of the country's entire manufacturing sector.⁵⁰⁴

The Australian cleantech sector is a productive one. It is estimated to create on average about five times the revenue per employee in comparison to general manufacturing and, with 0.07% of total registered companies, generating 2% of Australia's GDP.⁵⁰⁵ The Australian cleantech sector more broadly was involved in 126 separate capital transactions, including new equity, grants and acquisitions totalling \$1.3 billion during the 2012 calendar year.⁵⁰⁶

497 DIISRTE Custom data request from the ABS (2012) *Innovation in Australian Business 2010–11*, cat. no. 8158.0. Data available on request.

498 Barbier EB (2011) Transaction costs and the transition to environmentally sustainable development, *Environmental Innovation and Societal Transitions*, 1, 58–69.

499 Australian Government (2012) *Australian Innovation System Report – 2012*, DIISRTE, Canberra, p.56.

500 ABS (2010) *Energy, Water and Environment Management, 2008–09*, cat. no. 4666.0.

501 Chong J, Asker S, O'Rourke A & White S (2012) *Green Chrysalis—Small and medium-sized enterprises: Innovation and transformation towards Australia's low-carbon economy*, Report prepared for the Australian Business Foundation by the Institute for Sustainable Futures, University of Technology, Sydney.

502 Where cleantech data is referenced in this report, the reader is encouraged to review original source material for full definitions of 'cleantech' as each report has its own definition.

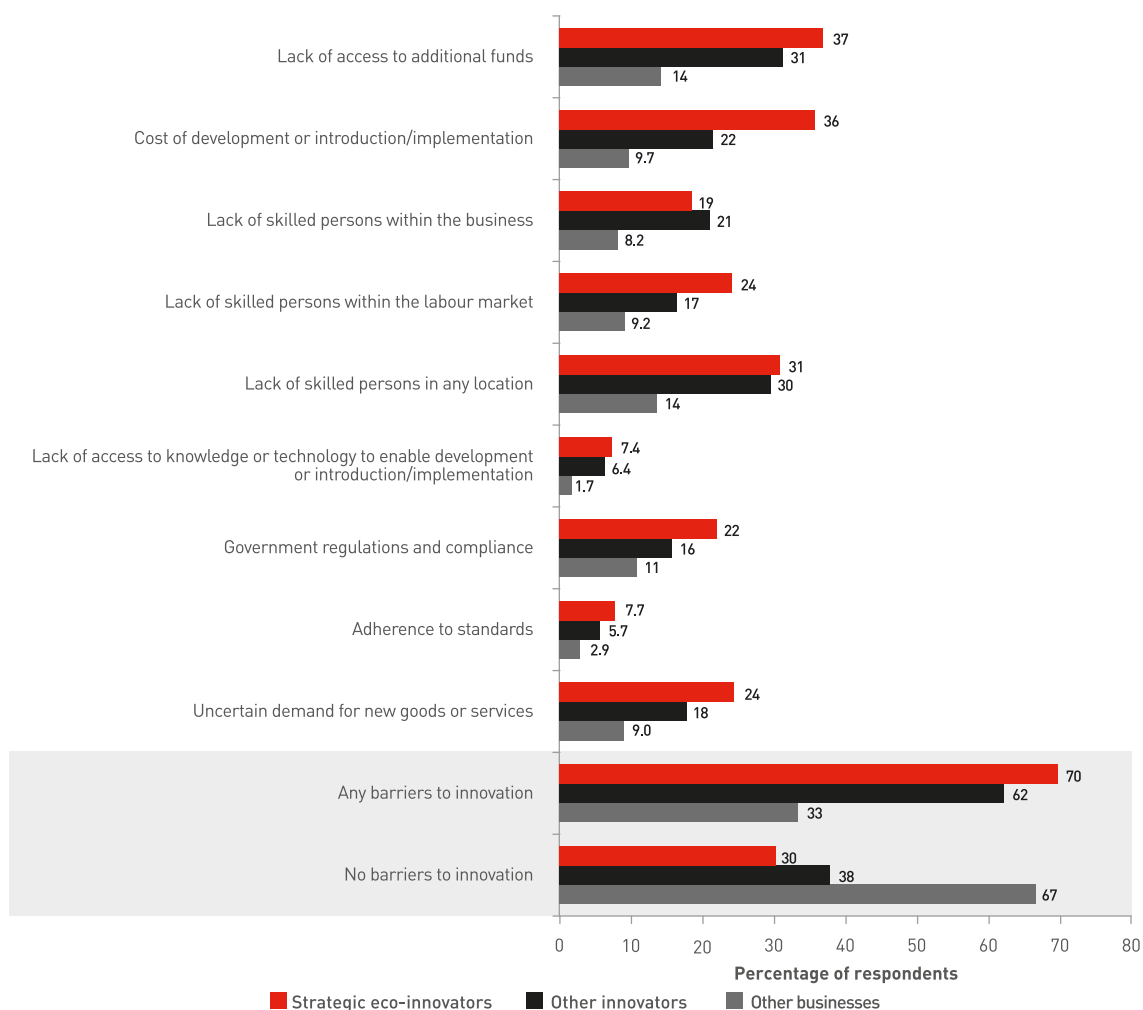
503 Bloomberg New Energy Finance, <http://about.bnef.com/resource-center/> [Accessed 1 June 2013].

504 Australian CleanTech (2013) *Australian Cleantech Review 2013*, Australian CleanTech, Goodwood, South Australia.

505 *Ibid.*

506 *Ibid.*

Chart 5.14 Barriers to innovation, by innovation status, 2010–11



Source: DIISRTE Custom data request from the ABS (2012) *Innovation in Australian Business 2010–11*, cat. no. 8158.0

According to the 2012 Global Cleantech Innovation Index⁵⁰⁷ Australia ranks 16th globally (14th in the OECD) in overall score. This performance is marginally better than other global innovation rankings (see Introduction). Interestingly, Australia ranks third on the *Inputs to innovation* score, which includes general innovation conditions that facilitate technology start-up businesses such as infrastructure and culture (Australia ranks 3rd), as well as cleantech-specific drivers such as cleantech policies (9th). Despite this, Australia appears unable to capitalise on this advantage—it achieves a poor *Outputs of innovation* score (at 22nd) driven by poorer performance in *Evidence of emerging cleantech innovation* (20th) and *Evidence of commercialised cleantech innovation* (22nd). This is partly due to structural factors such as a small domestic economy; however, Australia appears to have unusually low innovation system efficiency in cleantech innovation (Chart 5.15). The data suggests that this low system efficiency applies more broadly to the Australian innovation system (see also Introduction).⁵⁰⁸

507 Coming Clean: *The Global Cleantech Innovation Index 2012*, Cleantech Group and World WildlifeFund.

508 INSEAD & World Intellectual Property Organization (WIPO) (2012) *The Global Innovation Index 2012*, INSEAD, Fontainebleau, France.

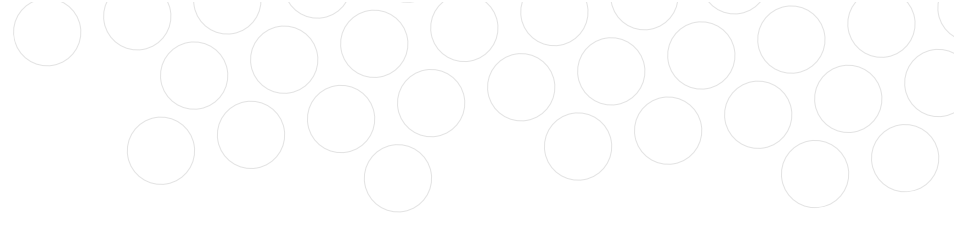
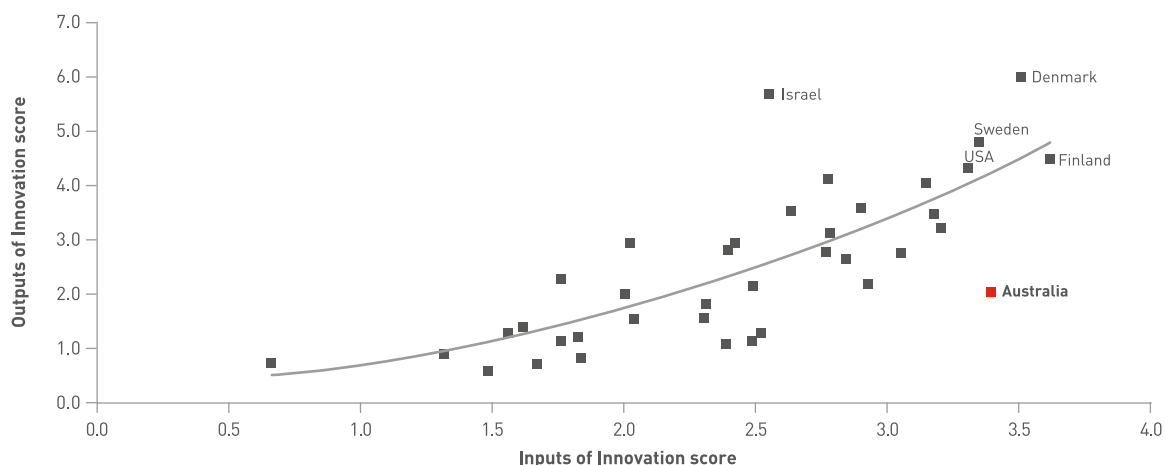


Chart 5.15 Cleantech innovation outputs and inputs scores, by country, 2012



Source: Cleantech Group and World Wildlife Fund (2012) *Coming clean: The global cleantech innovation index 2012*

FEATURE: GREEN GROWTH: THE NEXT INNOVATION FRONTIER



Caption: Samantha Sharpe



Caption: Stuart White

By Samantha Sharpe and Stuart White, Institute for Sustainable Futures, University of Technology, Sydney

The transition to a low carbon economy, or ‘green growth’ as it is sometimes called, will involve both immense opportunity and immense challenge. It is a transition that will involve moving to more efficient economic and production systems. The opportunities lie in the creation of new industries and employment that allow socio-economic development but also ensure the longevity our environment for current and future generations. The challenges lie in coordinating global activities to generate the necessary carbon

pollution reductions, and equitably managing the uneven consequences that these mitigation and adaptation activities will have across regions and nations.⁵⁰⁹

The global financial crisis (GFC) of 2008 and the resultant worldwide recession appeared to offer an opportunity to restructure economic systems. Some observers hoped that when leading economies came back from recession they would not return to ‘business as usual’ but would adopt a new economic reality – Economy 2.0 – that would balance natural capital with other forms of capital.⁵¹⁰ However, the continuing recession and austerity in many countries has stymied efforts towards green growth. The recent Rio+20 Summit and UNFCCC meetings also highlighted the global policy community’s inability to reach consensus on coordinated action to address climate change.

Crisis brings innovation and entrepreneurship to the fore, and despite the cautious approach at the international level, the potential and practice of green growth is being demonstrated by many jurisdictions at the national, regional and local levels. Australia has joined many developed and developing economies in legislating a price on carbon pollution, and in making significant investments in renewable energy. Local government authorities such as the City of Sydney are, with the support of their constituents, taking the initiative to reduce emissions in

509 See OECD (2012) *The jobs potential of a shift towards a low carbon economy*, OECD Publishing; and UNEP, International Labour Organisation (ILO), Institute of Education (IOE) & International Trade Union Confederation (ITUC) (2008) *Green Jobs—Towards decent work in a sustainable, low carbon world*, report produced by Worldwatch Institute and commissioned by UNEP, ILO, IOE & ITUC, Nairobi.

510 OECD (2011) *Towards Green Growth*, OECD Publishing.





their jurisdictions.⁵¹¹ In doing so they are pioneering new energy, waste and water systems that challenge the limits of traditional urban built environments.

Innovations in technologies such as Information and Communications Technology are further enabling green growth. The availability of high-speed internet connections allows real-time communication and the balancing of energy demand and supply. Mobile communications have enabled share-car operations and similar 'sharing' business models to flourish in urban areas. Resource efficiency is driving new forms of value creation in recycling materials previously viewed only as waste.⁵¹²

Australia's (eco) innovation system

Australia emerged from the GFC in good shape. Our geographical location, once considered a disadvantage when matched with our small domestic market, is no longer seen as a liability in the Asian century. The opportunities for eco-innovations are immense. This paper highlights some current and emerging opportunities for eco-innovation in Australia.

Eco-innovations include the full spectrum of innovative activities, from technological solutions such as the installation of renewable energy systems, to process innovations for resource efficiency.⁵¹³ There is a knowledge-creation component to eco-innovation, involving the development and commercialisation of new products and processes. However, there is also an equally important knowledge diffusion component, where best practice and processes are communicated to, and adopted by, a large population of firms. Knowledge *creation* has a significant impact on the businesses involved, but knowledge *diffusion* has impacts at the economic and societal levels. If we are to fully achieve and benefit from green growth, we will need both the creation and the diffusion of knowledge.

Increasingly, innovation is best understood as a 'system' that includes many actors, with links and feedback loops between these actors. Progress, in this system, happens in fits and starts. Given this, the environment needed to stimulate innovation also goes beyond funding R&D and technology development, to include facilitating the transfer of knowledge, and collaborations between business, government and the tertiary education sector. Evidence shows that Australia consistently under-performs in measures of collaboration (DSIR 2012), and our investment in research and development activities is below the OECD average (2.21% of GDP versus OECD average of 2.33%⁵¹⁴).

There is a particularly low level of collaboration activity among small and medium-sized enterprises (SMEs), despite the recognised value of collaboration to promote innovation. Only 3.1% of SMEs collaborate in innovation with universities⁵¹⁵ although they make up 99% of the businesses in Australia, employ more than 40% of the Australian workforce and contribute almost half of Australia's gross national product (GDP).

If Australia is to maximise its opportunities and increase its competitiveness in the transition to a low carbon future, it must ensure the engagement of the SME business community in eco-innovation. This engagement must involve all SMEs and it will need to include knowledge creation and diffusion objectives. This highlights an ongoing policy challenge: the need to develop innovation support that meets the highly diverse needs of all actors within the innovation system. This challenge is further compounded by the fact that although we recognise the systemic nature of innovation, this understanding is not sufficiently reflected in the policy focus for innovation. The current focus is based on a market failure perspective, rather than recognising the wider systems failure.⁵¹⁶

Conditions which encourage collaboration between businesses and universities already exist in a number of models, including the CSIRO's Collaboration Clusters, and other problem-focused

511 For example see City of Sydney (2013) *Making it happen – clean, green infrastructure*, <http://www.sydney2030.com.au/development-in-2030/city-wide-projects/powering-sydney-allan-jones>, [accessed 4 March 2013].

512 Such as the recent collaboration cluster advertised by the CSIRO Minerals Down Under and Manufacturing flagships on estimating the value of greater metals recycling and understanding pathways to access this value.

513 Chong J, Asker S, O'Rourke A & White S (2012) *Green Chrysalis—Small and medium-sized enterprises: Innovation and transformation towards Australia's low-carbon economy*, Report prepared for the Australian Business Foundation by the Institute for Sustainable Futures, University of Technology, Sydney.

514 OECD Factbook (2011) *Economic, Environmental and Social Statistics*, OECD Publishing. Note: Although this is a significant improvement on the 2011 figure of 1.64% of GDP.

515 Australian Government (2012) *Australian Innovation System Report – 2012*, DIISRTE, Canberra.

516 Dodgson M, Hughes A, Foster J & Metcalfe S. (2011) Systems thinking, market failure, and the development of innovation policy: The case of Australia, *Research Policy*, 40(9), 1145–1156.





research grants. The recently announced federal government manufacturing hubs offer a similar environment. These models will need to be evaluated according to the collaborations they bring about, and this policy knowledge needs to be diffused. Innovation itself is changing, with more open models of knowledge sourcing and technology development becoming the norm.⁵¹⁷ The eco-innovation opportunities are immense, and so are the competitive forces, particularly from Asia.

How does and can Australia play a leading role?

There are four key areas, or domains, in which Australia could play a leading role in innovations to support green growth and eco-innovation.

The first is *energy and resource efficiency*. Australia's heavy reliance on energy and resources can be considered a burden in both economic terms⁵¹⁸ and in the more obvious environmental sense. However, there are opportunities that could come from the comparative advantage this reliance on energy and resources provides us. Australia has the opportunity, building on the introduction of carbon pricing and the establishment of the Clean Energy Fund, to develop and export technologies and expertise for decentralised energy⁵¹⁹ solutions (energy efficiency, peak demand management and distributed generation). Based on our research, the promotion of these solutions represents the main viable path to the greenhouse gas emission reductions needed to stabilise climate change. Australia also has huge potential for developing experience and expertise in large-scale centralised renewables, and solar thermal hybrids, which represent a useful transition pathway.⁵²⁰ We have the opportunity to move away from the 'dig it up and export it' trajectory to a path that involves the next generation of 'mining' used resources and pursuing advanced resource efficiency. We are living in a world that will be forced to recognise the limits imposed by: declines in ore concentrations, the need to reduce energy use, and the imperative to restrain increases in transport costs. We can look to a future in which we create wealth from waste and advanced manufacturing.⁵²¹

The second key area is *urban systems*, which will become increasingly important in a world where more than 50% of people live in cities, and where in China alone, the equivalent of a New York City is added to the urban population every year, with the attendant infrastructure and built form requirements. Australia, as a heavily urbanised country facing many problems of transition from a transport system based on the era of cheap oil, has much to learn and contribute. Smart and sustainable cities will maximise the use of information and communication technologies, and of innovative approaches to infrastructure systems, including transport, energy, water and materials flow.

The third area is innovation in the understanding, protection and management of our *natural systems*. This will be a key factor in the future, involving the protection of our biodiversity and unique natural assets, including the Great Barrier Reef, aquatic systems, rangelands and forest systems and the species that maintain their integrity. Understanding and valuing ecosystem services,⁵²² and innovative policy and regulatory approaches, will be required, and will place us in good stead for supporting our rapidly growing neighbours in similar pursuits.

The fourth key area, innovation in the *social and political* domains, should not be neglected. For example, Australia is already recognised for its contributions to democratic processes, including the use of innovations such as deliberative polls and citizens assemblies that engage citizens in decision making.⁵²³ We will need such innovative approaches if we are to bring the community along in facing the emerging challenges of this century.

517 Chesbrough H & Crowther A (2006) Beyond high tech: early adopters of open innovation in other industries, *R&D Management* 36(3), 229–236; Cosh A & Zhang J (2011) Open Innovation Choices—What is British Enterprise doing?, NESTA, London.

518 Corder M (2012) Dutch disease in Australia: Policy options for a three-speed economy, *The Australian Economic Review*, 45(3), 290–304.

519 Dunstan C, Boronyak L, Langham E, Ison N, Usher J, Cooper C & White S (2011) *Think small: The Australian decentralised energy roadmap*: Issue 1, December 2011, prepared for CSIRO Intelligent Grid Research Program, Institute for Sustainable Futures, UTS, Sydney.

520 Peterseim J, White S, Tadros A & Hellwig U (2013) Concentrated solar power hybrid plants, which technologies are best suited for hybridisation?, *Renewable Energy*, 57, 520.

521 UNEP and CSIRO (2011) *Resource Efficiency: economics and outlook for the Asia Pacific*, UNEP, Bangkok.

522 Plant RA, Hamstead M, Taylor C & Prior T (2012) *Recognising the broader benefits of aquatic systems in water planning: an ecosystem services approach*, Waterlines Report Series No. 87, August 2012, National Water Commission, Canberra, pp. 1–90.

523 See Carson L (2008) Creating Democratic Surplus through Citizens' Assemblies, *Journal of Public Deliberation*, 4:1 ; Herriman EJ, White S & Atherton AM (2012) *Political influence in the context of Australian WWViews*, In Font J (Ed), *Citizen Participation in Global Environmental Governance*, Earthscan, London, UK, pp. 221–240.





Concluding remarks

Australia could quickly become a global leader in the pursuit of a green growth strategy. Our geographical location, previously thought of as isolating us from key markets, is now regarded as an asset, due to our proximity to the world's most rapidly developing countries. The reality of resource, oil, atmospheric and energy constraints will inevitably be recognised and trade will increasingly be in high value-added commodities, wealth from waste, and trade in services and expertise. Australia's high skill base, combined with suitable encouragement of its emerging experience with eco-innovation, will enable our industries and researchers to contribute to the creation of a global economy that has decoupled development from increased resource and energy use and the destruction of biodiversity. Our competitive advantage can shift from primary industries to a more enduring future in eco-innovation.

Green growth opportunities in Asia

A particular focus on engagement with emerging Asian economies will be instrumental to Australia's sustainable economic growth. By 2030 the bulk of global GDP is expected to be generated from non OECD countries, especially China, India, Brazil and Russia.⁵²⁴ The population of the world is projected to be over 8 billion, with nearly 5 billion middle class consumers, the majority in Asia. It is expected that countries will be struggling to meet the increased demand for energy, water and food while at the same time meeting the environmental stresses of global warming, loss of species habitat, ocean acidification and over-harvesting of fauna and flora.⁵²⁵ These changes will create a massive market for innovative, environmentally sustainable goods and services. Billions of dollars' worth of export opportunities exist for early-mover Australian firms that can meet the demand for new innovative environmental solutions from developing countries such as India, China and Indonesia. Australia will therefore need to improve its development of relevant skills, new technologies and business models and new relationships to fully benefit from these rapid increases in Asian demand.⁵²⁶

Significant opportunities therefore exist for Australia in leading the world in eco-innovations such as clean technology, particularly for the sustainable uses of water, energy and mineral resources. Renewable energy sources alone are projected to account for about half of Australia's electricity generation by 2049–50,⁵²⁷ bringing with it opportunities to lead the world in related clean technology fields. By investing in eco-innovation, Australia is well positioned to provide tailored, sustainable solutions to Asian markets. Australia is recognised as one of the international leaders in water management and food production and its developing capability in low carbon services will provide further export opportunities. In addition, Australia's education sector (\$16.3 billion in exports in 2010–11) stands to reap benefits from the transition to a low carbon and circular economy domestically and regionally. Australia is well placed to be a regional hub for delivering green products, services, education and skills, helping ensure the AsiaPacific region will be at the forefront of the 21st century's global green economy.

Opportunities for trade, investment and collaboration on innovation exist where there is significant Australian business experience in managing scarce natural resources. Australia appears to perform better than the developing Asian countries of India, China and Indonesia in energy, non-energy material and biotic material productivity.⁵²⁸ Provision of innovative environmental consulting, community education, engineering design, project management and legal services for the waste management sectors of China, India, Vietnam and Indonesia is a major opportunity for Australia.⁵²⁹

Australia is recognised internationally for its project engineering expertise and research and development of new technologies in fields such as solar energy, geothermal energy and wave power. Australia is also renowned as a high-quality supplier of solar water heating systems and remote area power and hybrid

524 OECD (2010) *Perspectives on Global Development 2010: Shifting Wealth*, OECD Publishing.

525 National Sustainability Council (2013) *Sustainable Australia Report 2013*, Conversations with the future, Canberra, DSEWPac. Note: See comments from Garnaut R (2013) Australian opportunities through the Chinese Structural Transformation, Policy Forum: Australia's Economic Links with Asia, Faculty of Economics and Commerce, The University of Melbourne; and also <http://www.abc.net.au/news/2013-03-27/garnaut-warns-of-chinas-debt/4598544>.

526 National Sustainability Council (2013) *Sustainable Australia Report 2013*, Conversations with the future, Canberra, DSEWPac.

527 Syed A (2012) *Australian energy projections to 2049–50*, Bureau of Resources and Energy Economics, Canberra.

528 See OECD Green Growth indicators database, <http://stats.oecd.org>.

529 Harris J (2013) Opps for Australian waste managers in Asia, *WME magazine*, 24, pp.42–43.

systems.⁵³⁰ Recent analysis by the ATSE⁵³¹ has identified major green growth opportunities specific to Australia's comparative advantages and capabilities in the energy industry: the production and supply of sustainable liquid aviation fuels, low emissions electricity generation technologies and the management of intensely distributed electricity systems. Major Asian markets with the greatest opportunities for Australian clean energy and water exports include China, India and the ASEAN countries.⁵³²

The *CDP Water Disclosure Australia Report 2011*⁵³³ found that more than two-thirds of Australian companies operating in industry sectors that are water-intensive or are exposed to water-related risk identified water as a substantial risk to their business. Half of these businesses reported that they experienced detrimental water-related business impacts in the previous five years. This is more than the 38% that report such impacts globally. Within this challenge is an opportunity to take Australia's water innovations to international markets particularly other Asian countries. Australia can also continue to learn a great deal from highly water efficient Asian countries such as Singapore and Brunei. Government and industry participation in and support for Singapore's International Water Week is an excellent example of Australia's continued integration with Asia on environmental sustainability through innovation.⁵³⁴

China is experiencing the fastest growth in demand for environmental products and services in the world. It is estimated that environmental damage costs up to 8% of China's gross domestic product each year.⁵³⁵ China's environmental protection industry has developed in response to this growing environmental degradation over the past two decades. The industry produces the majority of its own goods and services for pollution control and environmental protection, though in some areas, the technology levels are low and below international standards. Therefore increasing investment in environmental protection is providing a range of opportunities for Australian companies.

An example of Australia's green growth opportunities in Asia is in the development of a Chinese market for membrane technology for water remediation. It is estimated that China's total output of environmental protection and energy conservation industry will account for over 7% of its GDP.⁵³⁶ The Chinese Government's 12th five-year plan (2011–2015) states there will be RMB3.4 trillion of investment demand in China's environment protection area from 2011 to 2015. RMB1.5 trillion of investment will be required in eight major prioritised projects, including water quality improvements.⁵³⁷ Depleting water reserves in China, especially northern China, have driven investment in effective water regeneration technologies. The 12th five-year plan provides further guidelines for water reclamation and reuse and the Ministry of Environment Protection of China strongly encourages the widespread use of membrane bioreactor technology. Membrane bioreactors have therefore emerged as the water treatment and reclamation technology of choice among both municipal and industrial end users. The Chinese market has witnessed exponential growth in the past three to four years and is expected to maintain this momentum. New analysis from Frost & Sullivan⁵³⁸ finds that this market earned revenues of \$228.1 million in 2010 and estimates this to reach \$1.35 billion in 2017.

Australia has world-class capabilities in research and development, project management, engineering and technology to provide solutions to water scarcity at affordable cost.⁵³⁹ Significant investment in R&D and commercial demonstration of reliable membranes for recycling has taken place in Australia. Support by government and regulatory bodies for a skills certification framework, R&D, a strong culture of innovation in both public and private sectors, and Australia's reputation as a hub for technology trials have enabled water and wastewater treatment plants to adapt quickly to the use of membrane systems.⁵⁴⁰ The establishment of research hubs such as the Australia China Joint Research Centre for River Basin Management,⁵⁴¹ the Australian Water Recycling Centre of Excellence,⁵⁴² the National Centre of Excellence in Desalination⁵⁴³ and core water business innovators such as MemCor⁵⁴⁴ and Osmoflo⁵⁴⁵ provides a critical mass in this market and has led to significant growth in the membrane technology market for water and wastewater treatment in Australia. Both public and private organisations are working together

530 www.austrade.gov.au/Clean-energy-overview [Accessed 7 May 2013].

531 Godfrey B, Sargent M & Pond S [2013] *Green growth – Energy: Industry opportunities for Australia*, Australian Academy of Technological Sciences and Engineering, Melbourne.

532 <http://www.austrade.gov.au/Clean-energy-overview/default.aspx> [Accessed 16 April 2013]

533 www.cdproject.net [Accessed 7 May 2013].

534 www.innovation.gov.au/WaterSupplierAdvocate [Accessed 7 May 2013].

535 www.austrade.gov.au/Export [Accessed 7 May 2013].

536 <http://www.austrade.gov.au/Environmental-technologies> [Accessed 7 May 2013].

537 www.austrade.gov.au [Accessed 7 May 2013].

538 www.frost.com [Accessed 7 May 2013].

539 Australian Government [2011] *Australia's Dynamic Water Industry*, Australian Trade Commission & DIISR, Canberra.

540 designbuildsource.com.au [Accessed 7 May 2013].

541 www.innovation.gov.au/JRCRiver [Accessed 4 June 2013].

542 <http://www.australianwaterrecycling.com.au/contact.html> [Accessed 7 May 2013].

543 <http://desalination.edu.au/> [Accessed 7 May 2013].

544 MemcorCaseStudy [Accessed 7 May 2013].

545 <http://www.osmoflo.com/> [Accessed 7 May 2013].

to take water innovation to Asian markets.⁵⁴⁶ With both Australia and China developing a certification framework to impart necessary skills to water treatment facility operators and boosting the market's preparedness for future developments, the Australian market has significant potential. Market-earned revenues for Australia and New Zealand surpassed US\$147.0 million in 2011 and are estimated to reach US\$237.9 million by 2017.⁵⁴⁷

Australia, with its strong domestic market and innovative capacity, is therefore in a strong position to compete for the Chinese market and other Asian markets along the full spectrum of the value chain. Australia ranks third in the OECD in the water pollution technology field and has a relatively high percentage (and volume) of Patent Cooperation Treaty patents in this area.⁵⁴⁸ Indonesia also has a relatively high focus on water pollution technology, but a very low volume of patenting in this space, suggesting another potential water technology market opportunity. Environmental improvement is one of the key priorities of Indonesia's latest National Medium Term Development Plan and addressing its heavily polluted river basins will be a major opportunity for Australia to share its institutional and technological innovations.⁵⁴⁹

Environmental goods and services⁵⁵⁰ markets

In 2012, the Asia Pacific Economic Cooperation (APEC)'s 21-member economies⁵⁵¹ reached agreement on an APEC List of 54 Environmental Goods on which tariffs will be reduced to no more than 5% by the end of 2015. The list includes core environmental products and technologies, such as renewable and low carbon energy technologies (e.g. solar, wind, gas and biomass energy generating equipment), water and waste treatment (e.g. air and water filtration equipment, recycling machinery and hazardous waste incinerators) and measuring and monitoring instruments (e.g. air and water quality monitoring equipment).

Australia played a lead role in finalising the environmental goods list.⁵⁵² The list was a major achievement for APEC as it:

- contributes towards green growth by boosting trade in products that reduce pollution, facilitate environmental management and lower carbon emissions.
- moves APEC closer to its goal of free and open trade and investment in the region.
- demonstrates that, despite the global economic downturn, a major group of economies can work together to open up trade.

546 See the Membranes and Desalination Conference <http://www.awa.asn.au/md13/> and the Asia-Pacific Water Recycling conferences <http://www.awa.asn.au/recycling13/> as two recent examples.

547 www.frost.com [Accessed 7 May 2013].

548 OECD (2011) *Towards Green Growth: Monitoring Progress*, OECD Publishing.

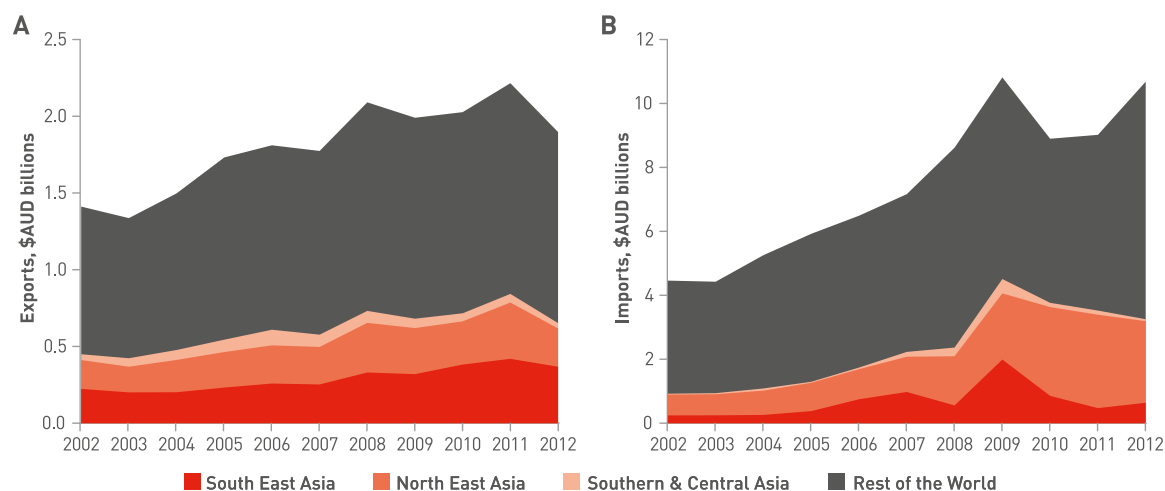
549 Hansnata E (2012) *Water management in Indonesia: Lessons from Australia*, East Asia Forum, 1 June 2013.

550 The environmental goods and services (EGS) sector has traditionally included solutions for problems such as air, noise and marine pollution, land and water contamination, as well as activities such as environmental analysis and consultancy and waste management and recycling. However more recently, the definition of this sector has widened to include a range of rapidly growing renewable energy technologies (such as hydro, wave and tidal power, geothermal, wind and biomass), as well as a number of other emerging low carbon activities (such as reduced emissions from within the transport and construction sectors, nuclear energy, energy management, carbon capture and storage and carbon finance).

551 APEC's member economies are: Australia, Brunei Darussalam, Canada, Chile, China, Hong Kong, Indonesia, Japan, Korea, Malaysia, Mexico, New Zealand, Papua New Guinea, Peru, the Philippines, Russia, Singapore, Chinese Taipei, Thailand, the United States and Vietnam.

552 The Australian Government is also negotiating the Trans-Pacific Partnership, a free trade agreement around the Pacific rim. Discussions have debated the inclusion of a chapter on the environment, biodiversity and climate change. See www.dfat.gov.au/fta/tpp.

Chart 5.16 Australian exports (panel A) and imports (panel B) of APEC54 environmental goods, 2002–2012



Source: Department of Foreign Affairs and Trade STARS database, based on ABS *International Trade in Goods and Services, Australia*, cat. no. 5368.0, February 2013 data.

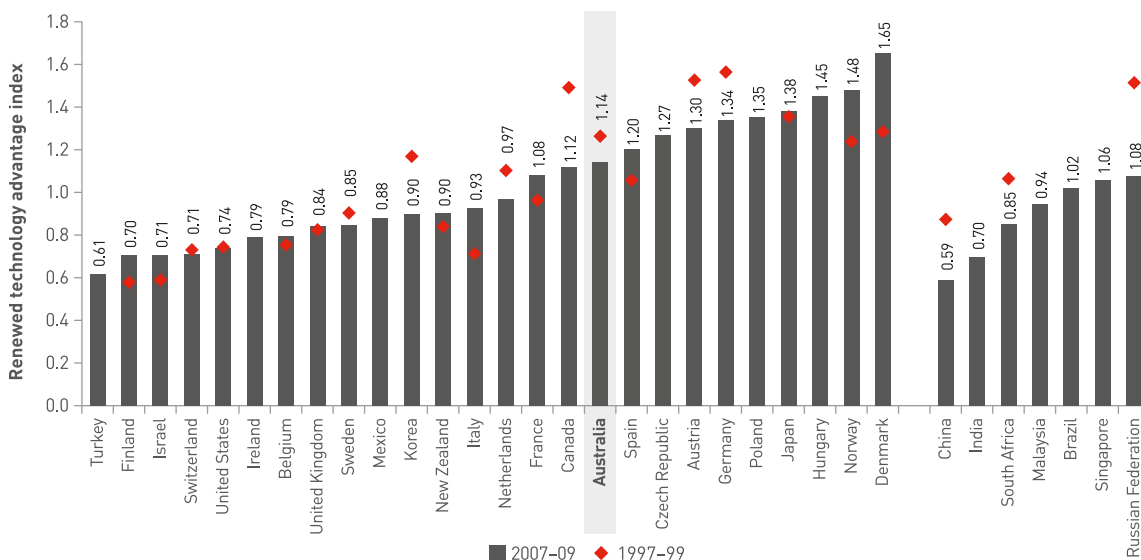
Note: Asian countries are defined in ABS (2011) *Standard Australian Classification of Countries, Second Edition, Revision 1*, Cat. No. 1269.0. Note the differences in scale between chart panels. Note that some volatility in the data can be the result of particular products being affected by confidentiality issues. For trade affected by confidentiality issues, the ABS delays or sometimes withholds the release of trade data to protect the identity of individual businesses.

Australia shows significant and growing trade in the APEC54 environmental goods with Asian countries, most notably southeast and northeast Asia. In 2012, Australia exported \$1.9 billion worth of these environmental goods globally, a 34% increase over the last ten years (Chart 5.16A). Over this same period the proportion of exports of these environmental goods to Asian countries has grown marginally to 34.4% in 2012. By contrast, Australia’s dependence on imports of the APEC54 environmental goods has grown rapidly to \$10.7 billion in 2012 up 140% in the last ten years (Chart 5.16B). The proportion of global imports of environmental goods coming from Asian countries has expanded from 21% to between 30% and 40% between 2002 and 2012. For reference Australia’s total imports and exports of all goods and services were both approximately \$25–27 billion per month in 2012.

The global value of low carbon, environmental goods and services⁵⁵³ was estimated at \$4.92 trillion in sales in 2010–11. Australia ranks 17th with its 1% share of total sales (\$49 billion) and currently sits with many other countries as a small player in this space. Together the top 10 countries (including the Asian countries of China, India, Japan, South Korea, Indonesia and Taiwan) account for 64% of global sales.⁵⁵⁴ When the size of the economy is taken into account, Australia ranking on the sales of environmental goods and services is not improved. However, Australia appears to have a more distinct advantage in terms of eco-innovation at both ends of the global value chain.⁵⁵⁵ OECD analysis of revealed technological advantage suggests that Australia performs relatively well on the development of environment-related technologies (Chart 5.17).

553 As defined by the UK Government and includes supply chain sales.
 554 UK Department for Business, Innovation and Skills (2012) *Low carbon environmental goods and services (LCEGS): Report for 2010/11*, Department for Business, Innovation and Skills, London.
 555 Godfrey B, Sargent M & Pond S (2013) *Green growth – Energy: Industry opportunities for Australia*, Australian Academy of Technological Sciences and Engineering, Melbourne, p.ii.

Chart 5.17 Revealed technology advantage in environment-related technologies, by country, 1997–1999 and 2007–2009



Source: OECD, Patent Database, February 2012.

Notes: Data relate to patent applications filed under the Patent Co-operation Treaty (PCT), at international phase. Patent counts are based on the priority date, the inventor's country of residence and fractional counts. The revealed technology advantage index is calculated as the share of country in patents filed in a given field relative to the share of country in total patents. Only economies with more than 500 patents over the periods are included in the figure.

As the OECD notes, there is considerable specialisation in green technology development across countries. Australia appears to have specialisations in renewable energy technology, which accounted for 1.56% of all patents (ranked 10th of 21 OECD countries), and water pollution (2.19%), where its share was the third highest of all countries.⁵⁵⁶

Rapid growth in emerging markets and global affluence has dramatically increased demand for materials, water and energy so prices of finite resources will continue to rise. These impacts on business will persist, if not intensify,⁵⁵⁷ as the measurement of environmental costs improves. The Australian innovation system should be oriented to address the green growth challenge by increasing the design, commercialisation, utilisation and uptake of innovative products, processes and services in Australia.

This is currently happening for greenhouse gas pollution and water intensity through broad systemic policy settings such as market regulation, pricing of waste, pollution and finite resources, and business cultural shifts. There are indications of an improvement in environmental management activities, and presumably eco-innovation, between 2008–09 and 2011–12.⁵⁵⁸ Some precursor innovation investments such as environmental R&D show rapid growth in recent years. With a lag effect, this increasing investment is expected to result in an increase in the rate of eco-innovation in subsequent years with ongoing policy certainty. Some Australian businesses have established a reputation as global leaders in disclosure and management of climate risks and opportunities⁵⁵⁹ and in developing business models that derive profit from sustainability.⁵⁶⁰

The systems, cultures and new business models pioneered and developed by Australian business with the support of others in the innovation system can provide the basis for Australia's continued prosperity and engagement with Asia. Australia can build on its current transition to a low carbon economy to spearhead the green economic transformation more broadly, thereby improving export-driven wealth and social equity for all Australians in the long term.

556 OECD (2011) *Towards Green Growth: Monitoring Progress*, OECD Publishing.

557 Dobbs R, Oppenheim J, Thompson F, Brinkman M & Zornes M (2011) *Resource revolution: Meeting the world's energy, materials, food and water needs*, McKinsey Global Institute and McKinsey Sustainability & Resource Productivity Practice.

558 The proportion of Businesses undertaking recycling or reuse of materials, environmental or 'green' purchasing activities, environmental education and training of staff, environmental impact assessment/risk assessment and measures to reduce pollution of soil, water and waterways have increased 145%, 211%, 229%, 146% and 120%, respectively, between 2008–09 and 2011–12. ABS (2013) *Energy Use, Electricity Generation and Environmental Management, Australia, 2011–12*. cat. no. 4660.0; ABS (2012) *Innovation in Australian Business 2010–11*, cat. no. 8158.0.

559 <http://www.climateinstitute.org.au/asset-owners-disclosure-project.html> [Accessed 1 July 2013].

560 Kiron D, Kruschwitz N, Haanaes K, Reeves M & Goh E (2013) *The Innovation Bottom Line, Research Report Winter 2013*, MIT Sloan Management Review and The Boston Consulting Group, Cambridge.

There are a large number of exciting case studies that show businesses and other individuals and organisations are investing in a transition to a cleaner, sustainable future. In addition to the case studies listed below, Chapter 2 has two highly relevant case studies on two growing businesses (F-cubed Australia and AquaGuardian) and their eco-innovations. Additional interesting case studies on Australian eco-innovation can be found in reports by the Australian Business Foundation, the OECD and several websites celebrating Australian eco-innovations.

CASE STUDY: FINANCING THE TRANSITION TO A LOW CARBON ECONOMY



Image provided by Westpac Banking Corporation

Whilst the environment and the economy are often seen at odds, the Westpac Group has been focusing on providing innovative solutions to help customers manage environmental challenges.

This has included active participation in international carbon trading schemes including the New Zealand emissions trading scheme on behalf of impacted clients as well as support for the renewable energy sector. Approximately 50% of Westpac's current lending to the energy sector is to renewable energy, including hydro.

But it has also been helping existing customers make the transition as well. In 2012 Westpac launched an energy efficiency lease for institutional customers to provide a cost effective way for large companies to fund activities that will cut their energy costs and emissions. There are plans underway to extend this product to other businesses as well.

Underpinning this has been changes to credit underwriting standards, the training of over 1,800 employees in climate and carbon risk and the embedding of broader environmental, social and governance considerations into credit processes, including a public position statement on financing sustainable energy available on the Group's website www.westpac.com.au

Advocacy has also been an important part of the approach, to raise awareness and understanding of the risks to business and how to manage them. This has included a program of client engagement supported by participation in public research including the Business Roundtable on Climate Change's Business Case for Early Action on Climate Change as well as The Climate Institute's report on climate change adaptation 'Coming Ready or Not', for example.

These actions have built on Westpac's strong performance within its own operations, reducing emissions by 40% between 1996 and 2008 and by a further 7% since this time. Westpac is also focusing on energy efficiency and waste management initiatives to reduce its footprint and has committed to be carbon neutral for the next five years.

In 2013, Westpac announced a target to make available up to \$6 billion for lending and investment to the CleanTech and environmental services sectors by 2017. To be eligible, activities must be over and above business as usual and produce an environmental outcome in the areas of waste, carbon farming, water, energy and the greening of the property sector for example. This commitment effectively doubles the Group's current exposure and will be achieved through a combination of specific product offerings and increased lending volumes to the sector.

Westpac has also committed to deliver one environmental product or service each year to help business and the community respond to big emerging environmental challenges.

The announcement was part of a broader five-year sustainability strategy aimed at addressing key emerging societal issues where the bank can play an active role.

For more information visit <http://www.westpac.com.au/about-westpac/sustainability-and-community>

CASE STUDY: SKILLS FOR SUSTAINABILITY – TAFE NSW – NORTH COAST INSTITUTE



Caption: North Coast TAFE students studying the Vocational Graduate Certificate in Education for Sustainability through the 2012 National Sustainability Champions Program. Image provided by Alicia Bates, North Coast TAFE.

Images provided by North Coast Institute

TAFE NSW – North Coast Institute (North Coast TAFE) is one of the largest regional registered training organisations in Australia. With 17 campuses extending from Taree on the mid-north coast of New South Wales to the Queensland border, with has approximately 45 000 students completing nationally recognised qualifications and training programs each year.

North Coast TAFE is located in one of the fastest growing regions in Australia which is also home to ecologically significant and vulnerable natural environments.

With sustainability of great importance to the communities of this region, North Coast TAFE has proudly achieved over 13 years of demonstrable outcomes including an organisation-wide policy of accountability for sustainability. Since a peak in energy use in 2006, North Coast TAFE has prevented the generation of 4486 tonnes of carbon emissions through energy efficiency measures and changed practices. Leak detection equipment has been the key to better management of our water resources – in one year alone, over 12 000 KL of water has been saved by early detection of otherwise undetectable leaks.

Collaboration and partnerships are critical to North Coast TAFE’s strategy for ecological sustainability, and sustainable practice is embedded across its qualifications, with specialist sustainability skills also on offer. Since 2007, North Coast TAFE has increased enrolments in sustainability units 7 fold, by building staff capability to respond to the National Green Skills Agreement and the inclusion of sustainability units in training package qualifications. Staff are supported and encouraged to embed sustainability across all aspects of the organisation, including using campuses as ‘living laboratories’ where real-life learning opportunities for sustainability are readily available for all students – not just those studying sustainability. Non





accredited training programs to support sustainable development, in place, in communities also feature.

An example of the outcomes achieved through North Coast TAFE's approach is the partnership with Namatjira Haven Drug and Alcohol Rehabilitation Centre. The organisation was keen to progress their sustainability goals, both to reduce operating costs and provide positive, sustainable experiences and life skills for their residents. Case Manager for Namatjira Haven, Greg Jarrett, said "the program trained not only the staff, but the residents, and our aim is that trained staff are able to carry that on to more residents coming through." As a result, the Northern Rivers based organisation has installed rainwater tanks and solar panels, increased waste management facilities and planted trees for wildlife. Fresh eggs and vegetables are sourced from the on-site chickens and vegetable plot.

For North Coast TAFE, it's not just about what sustainability skills are delivered, but also how they are delivered. The use of Education for Sustainability (EfS) principles and practices in our teaching, facilitates transformative learning allowing individuals to move beyond knowledge and awareness and deliver real change for sustainability. In partnership with Swinburne University of Technology and Tropical North Queensland Institute of TAFE, North Coast TAFE is leading the professional development of VET practitioners in EfS across Australia through delivery of the Vocational Graduate Certificate in Education and Training for Sustainability under the National Sustainability Champions Program. With the program now in its second year, graduates of the 2012 Program are recognised leaders in their RTO's and achieving outcomes in both organisational change and teaching and learning for sustainability. The partnership delivered the first ever National Education for Sustainability in VET Conference in February 2013.

As an asset manager, a resource user, a community partner and an educational institution, North Coast TAFE believes it has an undeniable obligation to demonstrate responsible stewardship of its resources and to work with others in the region to do the same.

For more information visit <http://northcoast.tafensw.edu.au/EcologicalSustainability>

CASE STUDY: PROJECT CATALYST

Introducing Project Catalyst

Mackay Whitsunday Sugarcane grower Tony Bugeja sums up Project Catalyst perfectly; “When we found out that sugarcane farming was harming the Great Barrier Reef, we were shocked. Once we knew what was happening, we wanted to do something about it. Project Catalyst helps us to do that. It takes our ideas and helps us to learn if they really work. If we can be economically and environmentally sound, that is the best way to go – everyone wants to look after the environment, but there’s no point being green if we are in the red.”



Caption: Sugarcane Grower Tony Bugeja

Project Catalyst aims to reduce the environmental footprint that sugarcane production has on freshwater quality and the Great Barrier Reef by speeding the identification and validation of cutting edge farming practices in the sugar industry. The program brings grower led farming innovations together with expert agronomic advice, economic analysis and environmental evaluation to quantify potential improvements to water quality at end of farm. Additionally the work showcases that innovations and the adoption of new technology when matched with farmer ingenuity can provide a platform which can yield a win/win for the farmer and the environment via the adoption of precision agriculture.

Project Catalyst started in 2008 with 19 Mackay Whitsunday sugarcane growers and has expanded to 78 growers, covering the surrounding sugarcane growing areas of Queensland’s wet and dry tropics.

By assessing farm management practices for the key outcomes of improved water quality, soil health, farm production efficiency and economics Catalyst is able to determine the innovations that have what it takes to keep farms sustainable and our environment in good shape. The program identifies new practices that can be rolled out if proven successful in the Project Catalyst testing ground, supporting State and Federal programs that aim to increase adoption of improved management practices.





With Natural Resource Management (NRM) groups Reef Catchments, NQ Dry Tropics and Terrain NRM partnering with The Coca-Cola Foundation, WWF and the Australian Government the program is an example of how multiple players from different backgrounds can work together to provide meaningful solutions to a common problem.

How does it work?

Innovative farmers are identified in each region and are contracted to be a partner in Project Catalyst; agreeing to continue their focus on innovation and improving total farming operations. Importantly the farmers also agree to be open in sharing their insights. Farmers involved in Project Catalyst are provided with independent agronomic support to run crop husbandry, water quality and economic assessments that integrate their own innovation aspirations with robust scientific support offered by the extension providers. This process allows for validation of the innovation on their property. The innovation must show signs of being economically and environmentally sustainable.

The Queensland Department of Agriculture Forestry and Fisheries conduct economic analysis of the trials annually to build an understanding of its profitability. NRM bodies determine the water quality outcome of the activity in conjunction with existing monitoring programs and/or through informed modelling. Not all projects are proven to be viable, but all learning's are valuable. The findings are shared in case studies, shed meetings, farm walks, reports, forums and presentations. Typically the trials have multiple benefits.

An important aspect of Project Catalyst is nurturing innovative growers. This is done through the agronomic support, assistance in applying for the Australian Government's Reef Rescue Water Quality Improvement Grants and bringing the growers together to discuss their work and hear about the latest research. The group is also involved in other research and has contributed to social and economic research being undertaken for Reef Rescue and the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program.

Water Quality Improvements

Project Catalyst Growers innovative and best management farm practices to improve runoff and drainage water quality of 101,725 megalitres on over 20,345ha, and delivered the following annual load reductions to the Great Barrier Reef Lagoon in 2011 (when compared with conventional farm management):

- 72 tonne/yr for particulate nitrogen.
- 34 tonne/yr for particulate phosphorus.
- 64 tonne/yr for dissolved inorganic nitrogen.
- 13 tonne/yr for filterable reactive phosphorus.
- 551 kg/yr for pesticide.

Additional improvements to 17,500 megalitres on 3500ha of land have come from 30 non Project Catalyst aligned sugarcane land managers that have adopted innovative practices identified and validated by Project Catalyst.





Caption: Project Catalyst Growers at the 2013 Project Catalyst Grower Forum in Cairns.

Images provided by Reef Catchments.

Economic improvements

Project Catalyst uses model farms on farm sizes of 50ha, 150ha and 300ha to communicate potential economic improvement of certain farming practices. Use of Controlled Traffic Farming with GPS technology has become more widely adopted, following Project Catalyst Trials. The Model Farm report from QDAFF includes an investment risk analysis. This shows that irrelevant of the cane price and tonnes of cane harvested, the adoption of controlled traffic farming means that higher gross margins will be achieved than without controlled traffic due to the lower land preparation costs, yield improvements and reduced harvest fuel use. This model farm scenario shows the economic outcomes on three farm sizes of adopting this practice on a medium sized (150ha) farm:

- **Conventional farming:** 50% chance of receiving a gross margin of over \$731 per hectare.
- **Controlled Traffic Farming:** 50% chance of a gross margin over \$854 per hectare.
- **Controlled Traffic with GPS:** 50% chance of a gross margin over \$912 per hectare.

Project Catalyst growers are also investigating the use of GPS for variable rate fertiliser application, improved record keeping and herbicide management. As this work progresses the full economic (and environmental) benefit of using GPS for precision agriculture will be better understood.

For more information visit www.reefcatchments.com.au