CHAPTER 6
Emerging opportunities and challenges

Introduction
By 2020, the Australian Government wants a national economy in which businesses of all sizes and in all sectors embrace innovation as the pathway to greater competitiveness, supported by policies that minimise barriers and maximise opportunities for commercialisation of new ideas. This chapter looks at cases of emerging challenges and opportunities to the national innovation system that influence our ability to meet this goal.

This chapter discusses the opportunities of transitioning our economy to a cleaner and more resource efficient one. This chapter also investigates the emergence of platform technologies, specifically biotechnology, nanotechnology and smart infrastructure, that have a range of characteristics that will help generate longer term productivity increases and economic growth to help manage the impact of an ageing population, climate change and other pressures. These technologies have the ability to underpin an increasing number of breakthrough innovations in products, services, and processes and to offer solutions to address major global and national challenges, such as medical treatments, energy generation and environmental remediation. This chapter also looks at the necessity of increased global engagement on innovation, particularly with China and India as emerging major trading and knowledge partners in our region.

Green growth: A new driver of innovation

Sustainability challenges are driving fundamental economic changes
Australia faces a number of critical sustainability challenges. As the driest inhabited continent with a climate characterised by weather extremes, we are exposed to ‘greater risks of climate change than any other developed country’. Australia is one of the most emissions and water intensive economies in the world; we also face a number of other threats including food security, biodiversity and land quality.

Green growth has the potential to secure Australia’s future prosperity by managing these "wicked problems". It relies on promoting and taking advantage of a number of current trends which, in combination, constitute a significant economic opportunity:

Consumer demand is changing. Consumers are modifying their behaviour to reduce their environmental footprint, for example by increasing energy and water efficiency, recycling, and avoiding brands with poor green reputations. This pattern has continued despite the global financial crisis and subsequent economic downturn. In many cases, consumers are willing to pay a price premium for green products, thus opening up green opportunities for business.

Financial markets are increasingly promoting positive green outcomes. Financial markets are supporting green outcomes both directly and indirectly. Socially responsible investment (SRI) funds selectively invest in companies and projects with good social and environmental outcomes while still maximising financial returns. In 2010, SRI funds managed an estimated US$3.07 trillion in assets in the United States, representing approximately 12% of the total marketplace investment. Individual investment choices can also contribute to this effect. Australia has the highest rate of private share ownership in the world, with ownership highest and growing fastest among groups more likely to be concerned about green issues: those with higher income and education levels, and young people.

Environmental risk factors are also increasingly being recognised in financial decisions by the broader financial community\(^{295}\), indirectly making it more difficult for companies to obtain finance for environmentally risky projects.

**Governments are promoting change.** Governments are playing a crucial role by addressing key market failures, educating consumers and providing incentives for the development of green products and services. For example, Australia’s Renewable Energy Target will ensure that at least 20% of Australia’s electricity will be generated by renewable energy sources by 2020.

Governments also have an important indirect role in the development of markets and influencing consumer behaviour through the use of regulations, standards and consumer awareness programs. As one example, internationally developed emission standards for vehicles are having a significant effect on Australian exporters wishing to exploit low-emissions technology markets.

**Businesses are investing in innovation to reduce operating costs.** Many businesses are choosing to invest in more efficient production technology to stay competitive. While this can be capital intensive, it reduces operating costs in the long term, particularly as markets begin pricing environmental externalities. In the short term, businesses are also achieving cost savings throughout value chains by investing in innovative new or improved processes. For example, by repackaging or flat-packing stock, companies are able to get more of the product on the ship, truck and shelf, reducing logistics, fuel, pollution and out-of-stock costs. The impacts are increased when major companies require their suppliers to meet certain green standards.

### The role of innovation

The combined result is a massively increased demand for green technologies, products, services and skills, driving rapid expansion in green markets. This trend is expected to continue with global green markets projected to double from US$1.4 trillion per year to US$2.7 trillion by 2020.\(^{296}\) As noted in the introductory chapter, international organisations such as the Organisation for Economic Co-operation and Development (OECD) are already recognising this green growth potential.

Critically, innovation is at the heart of taking advantage of these opportunities. Innovation delivers new ideas, new ways of doing business, new markets and new jobs. These are the tools of transformational change. As resource use continues to grow there will be a point at which outcomes that are simultaneously economically, environmentally and socially beneficial will be limited by the continued depletion of natural capital. Innovation, both through the development of radical new solutions and the spread of incremental improvements throughout the economy, will be the key to doing more with less, enabling continued growth beyond present limits.

Innovation for green growth will thus involve two quite different processes. The first focuses on research and development to invent new technologies and solutions that can support a green growth transformation.\(^{297}\) New energy delivery techniques, alternate transport solutions, novel agricultural processes and improved communication tools are just a few examples. Such radical innovation requires the continuous strengthening of Australia’s public sector research capabilities. As outlined in Chapter 4, there is a need to enhance collaboration between public and private organisations to strengthen research and development, support commercialisation of new technologies and catalyse the emergence of new industries.\(^{298}\) Other key issues to be addressed include assisting innovative businesses gain access to finance, addressing inadequate business management experience and maintaining effective legal frameworks to support the commercialisation process.

The second process recognises that innovation for green growth is not just about new technology or inventions. It is also about greening the existing economy by increasing resource efficiency and implementing new production processes, business models, and communication strategies.\(^{299}\) Unfortunately, many businesses simply do not have the time or resources to adequately respond to green growth challenges and opportunities. Green growth potential often remains unrecognised or unexplored, due to a lack of information, inadequate skills, or perception that it is peripheral to the bottom line. In other cases, cleaning up business operations may require significant investment or retooling. Government programs to overcome these failures and ease restrictions on business access to finance will be a big contribution to business embracing green growth.

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298 See Priorities 5-6, Powering Ideas: An Innovation Agenda for the 21st Century.
While these challenges are not new, and largely no different to those facing the broader innovation system, failing to address them brings particularly significant risks in the context of green growth. Not only would Australia suffer from continued environmental degradation, it could also substantially miss out on big opportunities in a highly competitive global economy.

Australia enjoys a variety of excellent natural resources, a strong economy, proximity to booming economies in Asia, highly skilled workforce, world-class research capability, a rich ecology and deep cultural heritage. Recognising these advantages, as well as key challenges, allows Australia to optimise its pursuit of green growth. For example, specific opportunities exist to:

- Leverage our extensive renewable resources to become a testing ground for new technology;
- Develop the bio-economy;
- Enhance the impact of green service opportunities (especially through improvements in information and communication technology (ICT));
- Promote a green transformation in the manufacturing industry; and
- Achieve building efficiency improvements.

This means many Australian companies must reconsider some of their current approaches and practices and pursue green growth strategies to take advantage of the opportunities that the green global marketplace offers.

Platform technologies in the Australian Innovation System

Nanotechnology

Nanotechnology enables the purposeful engineering of matter at near atomic or molecular scales. This offers the possibility of new industrial applications in a very broad range of sectors including energy production and storage, filtration of contaminated water for drinking, hygienic food packaging, drug delivery and, in the future, new ways to regenerate damaged parts of the human body, including blood vessels, brain, nerves, bone and cartilage. Nanotechnology is expected to lead to many additional and qualitatively new applications in response to societal needs. Market analysis predicts very large markets for nanotechnology-enabled products, and forecasts suggest that many new jobs may be created. Nanotechnology is therefore receiving a lot of attention in many countries through government policies and considerable investments in research and development (R&D) and related nanoscience infrastructure. It has been estimated that in 2009 global government investments in this field totalled about $7.8 billion.

Nanotechnology is a thriving field of research, development and commercialisation in Australia with a strong reputation for scientific and technological creativity in areas such as nano-materials, nanobiotechnology, electronics and photonics, energy and environment and quantum technology. Australia has more than 75 nanotechnology research organisations and around 80 nanotechnology companies ensuring a rich flow of commercial products. These products range from delivering energy solutions, such as the Australian firm Dyesol’s dye solar cell (Chapter 3), to delivering medical solutions, such as Starpharma’s VivaGel® to prevent the transmission of sexually transmitted infections and Sonoeye™ from Seagull Technologies which uses a combination of nanotechnology and ultrasound to replace injections with non-invasively deliver drugs.

The bulk of nanotechnology research is undertaken at universities and research institutions including Cooperative Research Centres, Centres of Excellence, the Australian Nuclear Science and Technology Organisation and the Commonwealth Scientific and Industrial Research Organisation (CSIRO). Infrastructure investments such as the Australian Synchrotron and the Australian National Fabrication Facility also provide new product development platforms and world class facilities. Collaboration is therefore a defining feature of the Australian nanotechnology sector, with the country’s research institutes and private companies having formed strong alliances to bring products with commercial and social benefits quickly to market.

Australia is renowned for its strong R&D credentials; innovative and highly skilled scientists, and enterprising workforce. Collaboration with universities and ‘star scientists’ is important, especially for small companies.

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300 ibid.
Larger companies in relatively mature nanotechnology areas appear to focus more on applications that are driven by market demand. They also tend to collaborate with a broader range of organisations to leverage their in-house R&D.

Nanotechnology is a complex field owing to its dependency on various scientific disciplines, research/engineering approaches and advanced instrumentation. These features of nanotechnology can often create barriers to entry, particularly for smaller companies which have limited research, management and other resources. As most of Australian nanotechnology firms are small and medium enterprises (SMEs), it is important to understand the resource limitations faced by SMEs in this complex field, and identify market positions where SMEs are more resilient and competitive.

Like other firms in the Australian innovation system, nanotechnology firms face challenges associated with the recruitment and retention of human resources, especially people with highly technical and managerial skills to support R&D and production activities. Nanotechnology firms also need employees who can combine specialist and general knowledge (knowledge integration) and manage interdisciplinary teams.

There are also considerable challenges associated with the poor scalability process of R&D. This means that costs and prolonged lead times for new product development represent a major barrier for start-ups and SMEs, making nanotechnology less attractive to investors.

Nanotechnology may produce new materials with harmful effects on humans and the environment. Just as the many potential benefits of using man-made nanomaterials are being discovered, many of the potential risks are not fully understood. In order to manage any possible risks, businesses, regulators and community members must undertake risk identification, management and mitigation processes.

Figure 6.1: Regulation of nanomaterials

Equally important, intellectual property rights may become an issue as commercialisation progresses and nanotechnology matures. There is already a very wide range of patent claims that could act as a barrier for new entrants to the industry.

As much of the research activity is happening in universities, cultural differences between universities and firms may inhibit technology transfer processes and stall the achievement of significant outcomes. Strong collaboration and linkages between organisations and people involved in nanotechnology research and production are crucial to overcome these cultural differences and optimise the evolution of the industry to bring nano products from university or government research to the market.

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305 Ibid
306 Ibid
The Australian Government is committed to addressing the challenges associated with developing nanotechnology in the areas of health, safety, measurement capability, environment and regulatory impacts. It also recognises the need to engage with the community to both increase public understanding of the technology and to increase the understanding of technology developers and government about the public’s concerns and aspirations. The Government has initiatives in place that aim to promote the responsible uptake of nanotechnology, in particular through the National Enabling Technologies Strategy and Commercialisation Australia. Australia is not alone in addressing these issues. The international nature of the challenges provides an opportunity to create new networks and work collaboratively. Through forums such as the OECD and the International Organization for Standardization (ISO), Australia is actively engaging to develop internationally consistent protocols and terminology. Australia’s participation in the OECD Working Party on Manufactured Nanomaterials has enabled Australian researchers to participate in developing international solutions.

A strong illustration of the opportunities and the challenges presented by nanotechnology is presented by carbon nanotubes. When carbon is burnt in helium gas, carbon nanotubes form part of the soot. The tubes are only a few nanometres in diameter, but can be a few millimetres long. They have extraordinary strength and can conduct electricity and heat. The CSIRO is spinning carbon nanotubes into yarn opening up many new possibilities for their uses. It is early days in the research, but possible applications for carbon nanotube yarn might include bullet-proof materials and energy storage. But research has shown that some forms of carbon nanotubes may present risks if inhaled. The CSIRO and other Australian government organisations are undertaking research to better understand the risks presented by carbon nanotubes and to support their safe handling in the workplace.

The Australian Biotechnology Sector

Biotechnology refers to the use of living organisms, or their products, to modify human health and the human environment and generate industrially useful products and processes.

Australia is home to around 470 biotechnology companies, ranging from start-ups to more developed companies who are selling products in Australia and overseas. The vast majority of Australian biotechnology companies fall within the human therapeutics and diagnostics markets; however biotechnology is also used by Australian companies in industrial processing, agriculture and environmental processes. The sector includes a large number of research-intensive SMEs. Many are spin-outs from universities, other publicly funded research agencies and not-for-profit research organisations.

Data from the Australian Stock Exchange shows that although the global financial crisis adversely affected the Australian biotechnology sector, it was able to recover and ended 2010 on a high. Many Australian biotechnology firms are reaching critical milestones such as entering or completing phase II and phase III trials, filing applications to the US Food and Drugs Administration, and taking products to other international markets.

Australia’s biotechnology strengths include a world-class science base and infrastructure to support R&D, a culture of collaboration, and a transparent and efficient regulatory system. Moreover, Australia is one of the least costly countries in the industrialised world to set up a business. While Australia’s geographical remoteness from major markets, such as the USA, has historically made international partnerships challenging, our proximity to the strongly growing Asian region is an advantage.

There are a number of opportunity areas for biotechnology-related investments at both the research or commercialisation stage for biomedical (pharmaceuticals and regenerative medicine), agriculture (see earlier case studies in this report) and industrial biotechnology.

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312 Phase II clinical trials include initial assessment of drug performance, dosing requirements and efficacy.
313 Phase III clinical trials include definitive assessment of the drug efficiency, performance and safety.
Some examples include:

**Regenerative medicine:** The Australian Regenerative Medicine Institute, when at full capacity, will be one of the world’s largest regenerative medicine and stem cell research centres. Its research is looking to prevent or reverse conditions such as neurodegenerative disorders, diabetes and arthritis.\(^{315}\)

**Biodiscovery:** Australia’s exceptional biodiversity offers great opportunities for biodiscovery. Australian researchers can access large numbers of unique compounds and organisms which may be used in drugs, insecticides, herbicides or industrial enzymes. One example is the work by the Australian Institute of Marine Sciences in exploring Australia’s marine biodiversity for attributes with potential commercial application.\(^{316}\)

To ensure that the biological resources are used in ecologically sustainable and ethical manner, Australia is a signatory to the Convention of Biological Diversity, and has a nationally consistent approach for access to, and utilisation of, its biodiversity\(^{317}\).

**Industrial biotechnology** enables the development of both environmentally and economically sustainable manufacturing processes. Opportunities are likely to increase in areas such as biomaterials for medical products, biopolymers and a range of materials derived from alternative sources such as waste products and biomass. These technologies have significant potential to reduce industrial greenhouse gas emissions by replacing petrochemical feedstocks. For example, biomass can be used in the manufacturing of commodities such as fuels, chemicals and plastics. There is an increasing global market for biofuels, and other bio-based materials such as bioplastics. Australia’s large and technologically advanced local mining industry provides a sound platform for the development of bio-mining, the use of micro-organisms to extract metal from ores.\(^{318}\)

Many of the challenges faced by the Australian biotechnology sector are shared with other high-tech sectors. Start-up biomedical companies often face difficulties in attracting investment due to the lengthy development time of their products before they become commercially viable, referred to as the commercialisation ‘valley of death.’ This is particularly the case in Australia as the amount of available venture capital for early-stage, high risk companies is relatively small (see Chapter 3). Any potential restrictions to securing intellectual property, such as patents, may affect biotech companies negatively, as patents are often their sole assets, and thus central to attracting pre-commercial investments. Attracting and retaining highly skilled senior managers in companies is an additional challenge.

Biotechnology may also pose new health, safety or environmental risks and raise ethical concerns. For example, the use of Genetically Modified Organisms or GMOs in food production has improved crop yields; however, it has also raised community concerns. Governments face challenges in developing robust regulatory frameworks for new biotechnologies to effectively manage risks and address community views concerns without imposing unnecessary restrictions on researchers and industries.\(^{319}\)

Federal and state governments have established initiatives to address some of the challenges faced by the biotech sector. Federal initiatives to support R&D and commercialisation include Commercialisation Australia, the Innovation Investment Follow-on Fund and the R&D Tax Concession/Credit. Enterprise Connect offers advice and support to eligible SMEs, including access to specialised business advisors.

Examples of state initiatives to support the biotech sector include the Victorian Biotechnology Strategic Development Plan\(^{320}\), Bio Innovation South Australia,\(^{321}\) the Queensland BioCapital Fund,\(^{322}\) and NSW Department of Primary Industries\(^{323}\).

The sector also benefits from investments in science and research capabilities: One-third of the current 42 Cooperative Research Centres are involved in some aspect of biotechnology. The National Collaborative Research Infrastructure Strategy and the Future Industries Initiative both contribute to expanding national biotechnology capabilities, while Super Science Fellowships provide funding for early career scientists.

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315 For further information see [http://www.armi.org.au](http://www.armi.org.au)
316 For further information see [http://www.aims.gov.au](http://www.aims.gov.au)
In 2007, the Government released an *Industrial Biotechnology Strategy* focussed on increasing awareness of the benefits that industrial biotechnology can offer Australian manufacturing industries. The strategy is currently being further developed to take into account increased international attention on the environmental advantages and feedstock security offered by the use of biomass and biorefinery processes.

**Smart Infrastructure**

Smart infrastructure is where communications technologies are combined with hard infrastructure to make more efficient use of resources. Smart infrastructure offers potential gains for the transport, energy, communications, water and construction sectors where physical infrastructure is a critical framework condition for innovation. Smart infrastructure encompasses networked infrastructure that uses sensors and communications technologies to improve the efficiency of infrastructure and the associated services being delivered without being embedded into the infrastructure itself.

Examples of smart infrastructure include: smart meters for gas, water and electricity which communicate consumption to the utility provider for monitoring and billing; smart electricity grids which improve grid reliability and better utilise energy; transport systems which optimise traffic flows; smart water networks which improve irrigation productivity in agriculture; smart buildings; and a variety of new information services based on data gathered by sensor networks.

Smart infrastructure has the potential to transform the way we live and work. For example, technology is opening up ways to use new and existing transport infrastructure more efficiently. This will result in better traffic flows, lower energy consumption, and greater reliability of the system while delivering improved productivity, sustainability and liveability from our transport networks and for our cities.

Smart Infrastructure is also part of the digital economy – the global network of economic and social activities that are enabled by information and communications technologies, such as the internet, mobile and sensor networks. The benefits of smart infrastructure highlighted at the ThinkFuture Smart Infrastructure Conference 2010, include:

- Improvement on the abatement of Australia’s greenhouse gas emissions, through both more efficient energy use and significant reductions in congestions on our roads;
- Reduction in road traffic delays, and improved reliability of rail services, which will have both environmental and social benefits;
- Greater efficiency of water use both by industry and household consumers;
- Improvement in consumer choice regarding when and how to use their energy and water;
- Further social benefits of greater utilisation of tele-presence allowing employees to work from home;
- Supporting other smart infrastructure such as e-health, and better education services; and
- Faster identification of faults in both energy and water supply, and therefore faster repair.

Emerging uses of smart infrastructure enabled by information and communication technologies can assist in the management of resources, infrastructure and energy use. Such uses may also result in economic and productivity benefits that flow on from the adoption of smart technologies and systems in different parts of the economy. A study by Access Economics estimates that adopting smart technologies in electricity, irrigation, health, transport and broadband could add more than 70,000 jobs to the economy by 2014 and increase gross domestic product (GDP) by 1.5% over the next decade. Information and Communication Technology (ICT) has the potential to increase innovation by speeding up the diffusion of innovation, enabling networking among organisations, reducing geographic limitations and increasing efficiency in communication. OECD analysis shows that the probability of innovation significantly increases with the intensity of ICT use. Consistent with these international findings, innovating Australian businesses are much more likely to use information technology compared to non-innovators (Chart 6.1).

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325 A smart meter identifies consumption in more detail than a conventional meter. Smart meters communicate consumption information via a network back to the local utility for monitoring and billing purposes. They may also allow continuous measurement, time-of-day pricing information, and two-way communication between the device and the energy provider.


Governments around the world are increasingly adopting smart infrastructure policies to enhance competitiveness in the more sustainable economies of the future. The OECD is encouraging its members to develop expertise in smart infrastructure to assist in the short-run economic recovery from the global financial crises and lay the foundations for future growth. Smart electricity networks (smart grids) are seen to be of particular importance with the OECD describing smart grids as ‘an innovation with the potential to revolutionise the transmission, distribution and conservation of energy’ \(^{329}\). Just as the internet has spurred new innovations, applications and technologies, so will smart grids.

Additionally, the OECD states that sensor and sensor network applications show particular promise for tackling environmental challenges in energy, transport, industrial applications, precision agriculture and smart buildings. It has found that minimum standards of energy efficiency coupled with sensor technology can be a major factor in reducing electricity use and greenhouse gas emissions. \(^{330}\)

The *Digital Economy: Future Directions* paper \(^{331}\) provides some examples of smart infrastructure initiatives in Australia. It is anticipated that the successful demonstration of smart infrastructure will result in significant flow-on innovation and technology uptake across Australia.

Examples of Smart Infrastructure projects are:

- Smart Grid, Smart City initiative in Newcastle, NSW; \(^{332}\)
- CSIRO and the National ICT Australia (NICTA) Water Management initiative; \(^{333}\)
- NICTA’s Traffic Management initiative; \(^{334}\) and
- NICTA, SAP, and the Germany’s Fraunhofer Research Institute logistics initiative to launch the future logistics living lab in Sydney. \(^{335}\)

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Opportunities for the development and use of smart infrastructure in Australia will continue to emerge as new platforms for innovation including those provided by the National Broadband Network are progressed. The *Australia’s Digital Economy: Future Directions* paper outlined some of the key initiatives that are designed to pilot and promote smarter use of technology to manage our environment and infrastructure.\(^{336}\)

The *Realising Our Broadband Future Forum* that was held in December 2009 provided the opportunity for government, industry and the community to collaborate in developing a pathway to fulfil the vision of a ubiquitous, high-speed broadband-enabled digital economy including the opportunities and challenges related to smart infrastructure.\(^{337}\) Key areas where smart infrastructure can be used include:

- Smarter traffic control systems;
- Water management systems;
- Energy efficiency; and
- Teleworking.\(^{338}\)

For Australia to realise the many benefits and opportunities emerging technical, behavioural and funding challenges will need to be addressed and new services introduced. The key challenges for the sector were also highlighted by a Parliamentary inquiry in March 2010\(^{339}\) and *ThinkFuture* conference participants\(^{340}\) and included:

- Challenges posed by current regulatory environments across the sectors and the need for a national approach;
- A need for greater collaboration between industry players and across sectors;
- The need to prove the benefits of smart infrastructure and the requirement for greater investment in research and development and in skills for smart infrastructure;
- A need for a stronger focus on consumer engagement to promote the benefits of smart infrastructure; and
- Issues surrounding the collection, management and generation of data, including privacy concerns.

The Government’s National Broadband Network (NBN) initiative will allow all Australians, no matter where they live, to participate equally in the digital economy and the “sensor revolution”.

Tasmania will lead Australia in access to this new digital economy. Construction for Stage 2 has commenced and will pass 11,500 homes, with switch-on anticipated in March 2012. Planning is underway for Stage 3 which covers Burnie, Devonport, Launceston and part of Hobart (90,000 premises in total) and construction is scheduled to commence following completion of Stage 2. This first-starter advantage and critical mass of connections offers Tasmania the opportunity to attract ICT investment and to develop, test and demonstrate new applications, services and business models to the rest of Australia and beyond.

The goal of the Digital Futures Strategy (DFS), announced by the Tasmanian Government in August 2010, is to leverage the NBN to create an innovative, sustainable and vibrant Tasmanian digital economy. The strategy aims to prepare business and the community for the digital economy, and to assist the ICT industry, both local ICT research organisations and ICT businesses, to exploit opportunities for the development of NBN-capable applications, services and technologies. To achieve successful outcomes a coordinated approach is being undertaken between state projects, the recently announced Australian Government’s Digital Enterprise and Digital Hub programs and eLearning and eHealth agendas, Tasmanian ICT research organisations, Tasmanian peak industry bodies and NBN Co.

**Global Engagement and the Australian Innovation System – collaboration or competition**

Australia’s share in the production of the world’s knowledge (as measured by scientific publication output) is relatively high given our population size\(^{341}\) (Chapter 2). But at only 3.2% it is clear the majority of ideas and opportunities will arise internationally. Therefore, it is important that Australia keep pace with the rest of world in order to maintain its economic prosperity by enhancing its participation in global knowledge networks\(^{342}\). As global supply chains shift to where large markets emerge, multinational enterprises place a

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341 Science Watch – Annual Ranking of the Top 20 countries according to the research output and citation performers 2000-Aug 31 2010.

premium on broad innovation capabilities at the firm level in these regions. This section explores what are the opportunities and challenges of engagement with large, emerging markets such as China and India from both a national and business perspective.

The emergence of China and India brings with it many challenges and opportunities for the Australian innovation system. China and India have become significant trading partners for Australia. They have strong and extensive markets, strong purchasing power and are developing world class research capabilities. As a medium-sized, developed economy, Australia will face huge challenges to compete in terms of scale. Market size, improving R&D and design/engineering capacity and cheap talent are key factors driving investment decisions in innovative activities.

Large investment in business, infrastructure and innovation are taking place in the Asia-Pacific region and China is leading this growth globally. Using R&D expenditure as a proxy for innovation investments, Chart 6.2 shows the massive 21% per annum growth rate of China’s gross expenditure on research and development (GERD), a rate which more than doubles its own average annual GDP growth, and more than triples the OECD’s annual GERD growth.

![Chart 6.2: Annual growth rate of gross expenditure in research and development by country, 2000-2008]

Research and development spending in Asia surpassed European Union levels in 2005 and will probably overtake US levels in the next five years, largely due to China’s increased investment in research and development. In the last decade, China has become one of the world’s leading producers of high quality science. China is vigorously developing world-class research capabilities with rapidly increasing budgetary support. China now invests the third highest amount on research and development in the world (Chart 6.3). Chinese Government policies emphasise a long term commitment to science and research excellence.

Experienced researchers are becoming harder to find in the U.S. and Europe as Asian emigrant scientists return to more attractive opportunities at home. At the same time, industrial R&D organisations are increasingly establishing R&D facilities throughout Asia to take advantage of lower labour costs and larger pools of skilled scientists and engineers. Large proportions of multinationals corporations are choosing China and India as preferable locations for innovation investments.

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343 China and India are both ranked in the top 10 two way trading partners with China our top partner. Source http://www.dfat.gov.au/publications/trade/trade_at_a_glance_2010.html#ec02 (Accessed 20 April 2011)
345 Similar trends are observed in the annual growth of R&D expenditure, as indicated in the report Examining the Characteristics of Innovation Firms in Australia. Palangkaraya, A, et al. (2010)
346 Maiden M (11 December 2010) West must rise to the challenge as China sets the pace on many fronts The Age
The global innovation environment is seeking more innovation, science, engineering and managerial skills. Managerial skills in particular represent an important challenge for many Australian firms competing globally. The recent report ‘Management Matters in Australia’\textsuperscript{350} pointed out that ‘comparing Australian management performance internationally reveals that the top 27\% of Indian and Chinese manufacturers are better managed than half of Australian manufacturing firms. With these countries fast becoming global economic powerhouses, we can expect the proportion of relatively better-managed Indian and Chinese firms to increase.

\textbf{Chart 6.3:} Gross expenditure in research and development (GERD) and gross domestic product (indicated by size of the bubble) in selected countries, 2008

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Source: OECD Fact book 2010

The reliance on foreign-born skilled labour is set to rise further as the innovation skills base shifts toward Asia, notably China where there has been a significant increase in interest in these fields (Chapter 4). Immigration will be a short term solution to this shortage of innovation skills, however in the longer term Australia will require greater investment in innovation skills and capabilities\textsuperscript{351,352}.

In post secondary education, China’s share of global university enrolments has more than doubled to 15\%. Like other Asian countries it is specialising in science and engineering courses and is investing heavily to develop its leading universities to be the best in the world. Richard Levin\textsuperscript{353}, President of Yale University recently said “...China and India ... seek to expand the capacity of their systems of higher education [with China, in the last decade, doubling the number of universities from 1,022 to 2,263 at the present time] and aspire simultaneously to create a limited number of world-class universities to take their places among the best. While this seems an ambitious agenda, for China in particular, which has built the largest higher education sector in the world in just a decade, there is a will and commitment of resources to make it possible.”


\textsuperscript{352} See also Gittins R (2011) Making People employable is the key. Sydney Morning Herald, May 4.

\textsuperscript{353} Richard Levin quoted in an article by Jessica Shepherd (February 2010) China’s top universities will rival Oxbridge, say Yale President http://www.guardian.co.uk/education/2010/feb/02/chinese-universities-will-rival-oxbridge [Accessed 15 April 2011]
Although these trends show some of the features of the environment that Australia is (and will be) facing for collaboration, networking and competition there are a number of equally important framework conditions creating opportunities and challenges for global business engagement. In the case of China, for example, understanding culture, the nature of relationships, the workings of the Government, the needs for talent and skills and issues such as perceptions of quality, intellectual property and finance are fundamental steps for business to engage this market successfully.\(^{354}\)

While internationally culture influences business relationships, the difference about operating in China is the level, depth, and saturation point to which this occurs.\(^{355}\) In China, culture affects program and product development, human resources, manufacturing, marketing and sales, intellectual property, quality issues, servicing and speed to market, to name just a few. The cultural dimension is central to the execution of business strategy, and to achieving return on investment in China. Interestingly, these particular cultural characteristics of the Chinese market, together with technological advances such as internet based communication, open opportunities for a new breed of global SMEs or micro-multinationals. Global SMEs have flexibility and capacity to adopt new and effective business models for engaging with China.\(^{356}\)

The Government recognises the importance of enhancing Australian understanding of China in a global context and to this end has supported the establishment of a new Australian Centre for China in the World at the Australian National University (ANU) as part of the broader Commonwealth-ANU strategic relationship. Government support for the centre includes a foundation grant of $35 million and $18.1 million for the centre’s new building on the ANU campus. The centre will be an integrated, world-leading institution for Chinese Studies, producing innovative and high-quality research, widely disseminating this research, and providing postgraduate and other training activities. The Centre will take a broad holistic view and engage multidisciplinary expertise in areas including Chinese thought, culture, history, politics, society, environment, economics, and foreign and strategic policy. The Centre will also disseminate its research to the Australian Public Service.

Outside of the Australian Government other initiatives are taking place that aim to strengthen Australia’s engagement with China and India. The Queensland research and development investment strategy 2010–2020\(^{357}\) aims to build critical mass through development of international partnerships, including with India and China. The University of Queensland (UQ) Confucius Institute established in 2010 as a partnership between UQ, Tianjin University and the Office of Chinese Language Council International (Hanban) in China exemplifies this commitment. The UQ Confucius Institute is a science and technology focused institute that aims to facilitate academic and student exchange between UQ, Chinese Universities and research organisations and to combine the learning of Chinese language and culture with studies in science, engineering and technology. The promotion of science and technology collaboration between Australia and China and the encouragement of high-level forums, governments and corporate visits between the two countries are also important objectives of the institute.

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\(^{355}\) Ibid.


\(^{357}\) The 10 year Strategy provides focus to integrate departmental R&D investments on a whole-of-government basis and sets out what the Queensland Government wishes to achieve from R&D investments over the next ten years, and identifies the strategies and actions required to get there. http://www.chiefscientist.qld.gov.au/research-and-development/investment-strategy.aspx
The Australian Government also recognises the benefits of trade liberalisation, including the negotiation of comprehensive bilateral and multilateral Free Trade Agreements (FTAs) which cover all sectors of the economy. Australia is currently negotiating an FTA with China and has finalised a feasibility study on a possible FTA with India. Comprehensive FTAs with China and India would reduce barriers for innovative new companies to enter overseas markets, allow for greater business-to-business and business-to-government collaboration, facilitate the free flow of information, and provide significant economic benefits.

To tackle the increasing globalisation of the generation of knowledge, Australian organisations will need to strategically decide who and how to collaborate with others – internally and globally (Chapter 4). As already noted, Australia needs to focus on and expand its areas of expertise in order to take a lead in emerging global markets, especially those of its regional partners, China and India.

There are opportunities for Australian researchers and industry to form partnerships to take advantage of the fact that many Asian countries, China and India in particular, currently have significant investment capital available. While Australia cannot compete on scale, we can focus on our strengths and the priority areas for engagement and collaboration with these economies (for instance, energy, water, agriculture and health, as well as the emerging areas of interest – biotechnology, medical devices, engineering design and animal health). The new directions for Austrade (detailed in Chapter 3), the new Australia China Research Fund and the Australia India Strategic Research Fund are examples where the Australian Government is helping to establish collaborative innovation partnerships with Asia (detailed in Chapter 4 and below). In 2009–10 five Cooperative Research Centres (CRCs) reported commercial, research and educational alliances with seven organisations from India, and twelve reported commercial, research and educational alliances with 26 organisations from China.

Specialisation is one of the strategic choices that middle size countries such as Australia are facing. Specialisation means build world class capabilities and focus resources where Australian organisations can add value and differentiation.

Case Studies

The following case studies provide some insights into what is happening in the four areas of focus for this chapter. Additional case studies can be found in the case study companion to this report.

Zeobond’s ECO-CEMENT

According to the International Energy Agency, the manufacture of Portland cement produces about 0.9 kilograms of CO\(_2\) for every kilogram of cement. Around 5% of global CO\(_2\) emissions result from this process, making it one of the more polluting activities undertaken by mankind. One of the most promising alternatives to common Portland cement is geopolymer cement. Australia is now among the world leaders in research and commercialisation of geopolymer cement. Along with University of Melbourne researchers, CSIRO found that geopolymer technology reduces greenhouse gas emissions by 80% compared to Portland cement, because high temperature calcining (ore breakdown) is not needed. Geopolymer cement also has increased fire and chemical resistance. Even better, they can be manufactured from industrial waste stock, like the vast amounts of fly ash that are produced from coal combustion. If these waste streams reduce over time, geopolymers can be made from very commonly available materials, such as clays.

E-Crete uses waste fly ash and slag to achieve a comparable cement for an 80% emissions reduction. Image provided by Zeobond.
After almost two decades of development, private Melbourne-based company Zeobond Pty Ltd was formed in 2006 by researchers from the University of Melbourne to commercialise geopolymer cement. They created a new product called E-Crete which forms at room temperature, requires no kiln and uses fly ash as the main feedstock. The product looks similar to and performs in the same ways as concrete. It can also be used in most cases where concrete is used today, such as in ready-mix applications including house slabs, footpaths, driveways, and in pre-cast products such as bricks, blocks, pavers and panels. Zeobond laid the first test slab of E-Crete in 2007 and along with two other products are now being manufactured and used around Australia. Zeobond is also expanding into developing international markets where cement production is rapidly growing to meet infrastructure needs.

Life cycle analysis studies show that E-Crete produces 80–90% less carbon dioxide than traditional Portland cements for only 10% more cost than Portland cement, using existing supply chains. According to the Massachusetts Institute of Technology, approximately 2.35 billion tons of Portland cement is made each year. If carbon dioxide emissions in the global cement manufacturing sector can be reduced by even 10% this would accomplish one-fifth of the Kyoto Protocol 2012 goal of an average 5.2% reduction in developed country carbon dioxide emissions from 1990 levels. Zeobond’s successes shows that Australian research and development can punch above its weight in creating potentially world-changing eco-innovations.

New filters recycle 90% of company’s waste water

Drought and the fundamental need to stay in business have brought on a radical reengineering effort at Radford Meats in Warragul, Victoria. The company has gone through several transformations since opening in 1946, but the most recent will work to keep it in business, as well as help the environment. Water is essential in an abattoir and, with the assistance of the Australian Government, Radford has replaced its old water supply system with ultrafiltration technology – a red meat industry first. The ultrafiltration system is expected to recycle up to 90% of the water used at Radfords.

‘In drought conditions, using mains water in the volume required was not a viable option. We quickly realised that water recycling was our best option. Our previous system was fed by a natural spring on the company’s land and we realised we needed to do something when the spring began running dry up to once a week,’ Mr Radford said.

Before the ultrafiltration system was installed, waste water was pumped into the pasture from the settling ponds at the site. The new system will re-use the waste water and in a complementary development, we have modified our refrigeration plant to capture all defrost water that was previously wasted. Feeding the cold defrost water back into the system also greatly improves the energy efficiency of our cooling towers. Injecting this ‘pure’ water dilutes the overall effluent stream, reducing the load on the ultrafiltration system, and providing further energy savings.

Radford Meats has installed ceramic filters. The system filters waste to a microscopic level – less than 0.01 micron metres. Many people have shown interest in following the success of the system. Mr Radford believes that if each meat processor in Australia adopted an ultrafiltration system, up to 13 gigalitres of water could be saved each year.

‘We have tested and refined the system to adopt it to our needs and find ways to send as much of the water we use through the system. We are confident it will help us to keep growing.’ 359

The Western Australian State Agricultural Biotechnology Centre

The Western Australian State Agricultural Biotechnology Centre (SABC) is the major centre for agricultural biotechnology in WA. Led by Professor Michael Jones, this Murdoch University centre provides state-of-the-art facilities in molecular research and biotechnology for researchers of WA-based universities as well as the Department of Agriculture and Food WA. Operating under a “Research Hotel” model the SABC promotes collaborative research between different groups and also supports the incubation of start-up Ag-Biotech companies in WA, such as Saturn Biotech and Nemgenix. The income gained from researchers and the services provided, covers maintenance and running costs of equipment and facilities, such as OGTR and AQIS-approved laboratories, ‘Next generation’ DNA sequencing and mass spectrometers; yet provides access in a cost-effective and equitable manner.

The major research focus at the SABC is on molecular activities that involve or promote primary production of commercial livestock, crop plants or microbes, or their subsequent processing for added value. Because of its inclusive nature, the SABC also supports some research in biomedical sciences and environmental biotechnology.

SABC researchers have an outstanding track record of outcomes of benefit to the agricultural industry. These include:

- Provision of co-located, state-of-the art, well run platform technologies for all WA researchers;
- Averaging 50 current PhD students and 30 Honours students;
- Major advances in introgressing resistance to Russian Wheat Aphid in Australian wheat germplasm;
- First transcriptome sequence of a root lesion nematode;
- Significant plant virus research, including 7 new full length sequences of plant viruses, and identification of a new class of virus;
- Plant breeding support leading to improved crop varieties (molecular markers, yield, resistance to diseases and pests, better quality, variety ID, diagnostics);
- Improved productivity and health of livestock; and
- Biomedical diagnostics.

Bio-fortification of bananas for East Africa: planning for success and public acceptance

QUT researchers are on track to providing East Africa with access to disease-free bananas within the next two years. The bio-fortification project will ensure the future survival of the population’s staple food and improve its nutritional value.

The project has been funded by $10 million in grants from the Bill and Melinda Gates Foundation. Professor James Dale and his 13-strong research team are identifying and diagnosing the different viruses infecting East African Highland bananas, and micro-propagating varieties of bananas that are high in micronutrient content and disease free.

Ugandans are the largest consumers of bananas in the world and eat on average nearly one kilogram per person per day. Banana diseases have the potential to threaten the basis of their food supply and have a devastating effect on the banana industry. QUT scientists have been successfully researching methods to improve the nutrient content of the East African Highland banana through genetic improvement for the past 18 months.

Research partners include:

- National Agricultural Research Organisation Uganda;
- Kenyan Agricultural Research Institute;
- Mikocheni Agricultural Research Institute; and
- Africa Harvest Biotechnology Foundation International.

In 2010, the Department of Innovation, Industry Science and Research, as part of the National Enabling Technology Strategy, worked with Kristin Alford and her team at foresight consultancy Bridge8 Pty Ltd to improve and promote the AccessNano education resource with various small projects.

In January 2010, Bridge8 attracted 15 educators through the Australian Science Teacher Association (ASTA) network to attend a free workshop in Melbourne on AccessNano. The provision was that on return to their state or territory, the attendees would host their own workshop to assist other teachers in delivering this resource in schools. All but one attendee realised their promise to deliver a workshop to their schools between February and May 2010. The workshops were well received with 94% of attendees rating the experience as beneficial to highly beneficial. Furthermore, six of the original 15 teachers have committed to delivering additional workshops throughout the year at no extra charge to the Department.

By tapping into the enthusiasm these professionals possess, the Department benefited with additional work beyond the teachers’ initial commitment, allowing the dissemination of information on nanotechnology to continue at no extra cost, and encouraging a culture of collaboration to continue this dissemination process.

Bridge8 brings broad knowledge from its consultancy projects and expertise to inform opportunities for this resource and approaches to teaching, including the development of animations and support for teacher networks.

The Department of Innovation continues to work with Bridge8 to develop the AccessNano resource and new channels to distribute its content to assist in supporting this resource, including an education blog (http://science-education.govspace.gov.au) and YouTube channel (www.youtube.com/user/AccessNanoOrg).

Dr Ian Oppermann, Director of the CSIRO ICT Centre is heading up a project with the CSIRO’s Australian eHealth Research Centre (AEHRC) which aims to use information and communication technologies to build a sustainable healthcare system for Australia.

With access to high speed reliable communication opened up by the national rollout of the NBN, in conjunction with the development of easy to use/smart technologies, eHealth opens new mechanisms for healthcare service delivery in traditional healthcare facilities, community settings and in private homes.

The sustainability of health services in Australia requires a whole of system approach to service delivery. With health expenditure now in excess of $110 billion, health accounts for over 9% of Australia’s annual GDP. Dr Oppermann believes that against this backdrop the NBN has the ability to fundamentally change service delivery models in health services, human services and smart infrastructure services. Symmetric data rates (where upload rates are the same as download rates) will mean users can contribute to content creation helping to:

- Develop new cost-effective services to meet the demands of the health service providers and users;
- Respond to the complexity of health services provided and required; and
- Ensure greater access, irrespective of location and circumstance – house bound metropolitan to rural and remote locations.

Pilots of health services that are being enabled by new/smart technologies are taking place across the country. Smithton in Tasmania has seen the use of existing broadcasting infrastructure (namely analogue TV channels) to transmit information to those who live beyond current broadband networks; Armidale in northern New South Wales has had specialist health care delivered to remotely located patients; and the Pilbara in WA has trialled screening and early detection across a number of medical conditions, facilitated by video data transfer with Perth-based specialists.

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Recent trials carried out by CSIRO’s AEHRC, in partnership with Queensland Health, which use smartphones to deliver post operative cardiac care and monitoring have also proven to be very successful. The trial allowed patients and their health mentors to contribute to, and monitor, the patient’s healthy lifestyle programs (measuring the number of steps taken, entering wellness diary entries, sending and receiving daily motivational and educational text messages, etc), all delivered via a mobile phone. The trial has shown a significant increase in patient completion rates of post operative cardiac programs, which will lead to fewer re-admissions in the future.

The work being done by the AEHRC in the ehealth area demonstrates that the increasing demand on Australia’s health service, both in terms of volume and complexity, can be better met with an effective use of the NBN and associated technologies, by both providers and users of the health services in Australia.

Australia India Strategic Research Fund (AISRF) Project: TA010002

Under AISRF, in 2007 Monash University was granted total funding of $1.5 million over 3 years to support the establishment of a joint research academy with the Indian Institute of Technology, Bombay (IITB) [Mumbai]. The Research Academy is a partnership between two of the world’s leading educational and research institutions. Together IITB and Monash are taking a collaborative approach to multidisciplinary research that can effectively deliver high impact, integrated solutions to complex research problems for industry, government and the broader research community.

The academy, which opened in 2008, will soon be housed in a purpose-built $10 million facility. It has received funding support from the Australian and Indian governments and industry leaders from both countries. It currently has 54 PhD students with numbers expected to grow to 350 by 2016.

Doctoral students enrolled in the Academy are jointly supervised by researchers from the Monash Research Academy and IITB and receive a dually awarded PhD degree on completion. The postgraduate degree is designed to work closely with industry partners. Degrees will be awarded across six research themes: computational science and engineering; infrastructure engineering; biotechnology and stem-cell research; clean energy; water; and nanotechnology. Students will conduct most of their research at the Academy’s premises in the Powai campus of IITB, but will spend around six months in Australia with their Monash University supervisor.

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China connection

In September 2010 Professor Jinghai Li, Vice-President of the Chinese Academy of Sciences (CAS), and Professor Rongqiao He from the Chinese Academy of Sciences’ Institute of Biophysics (IPB; a CAS institute in Beijing) visited the Queensland Brain Institute (QBI) at The University of Queensland (UQ), joining QBI Director Professor Perry Bartlett to officially open the Queensland node of the QBI-IBP Joint Laboratory of Neuroscience and Cognition. The launch of the Beijing node of the joint laboratory followed in November 2010. The establishment of this world-first joint neuroscience laboratory with China consummates the strong relationship between the two institutes, harnessing their synergies in neuroscience.

Understanding how functions such as attention, learning and memory are regulated in the healthy brain, as well as in disease or injury, is one of the major challenges facing modern neuroscientists. This initiative brings together expertise and advanced technologies in cellular and molecular systems, imaging and protein chemistry to address these issues, with the long term goal of developing new approaches to treat neurological and mental disease.

The joint laboratory will focus on research into:

> The brain’s attention processing system – specifically selective attention in learning and memory, a hallmark of many debilitating psychiatric and neurological conditions;
> The production of new brain cells and neurons, known as neurogenesis, and its role in learning and memory; and
> The brain’s synaptic circuits in learning and memory, as well as in anxiety and depression.

Understanding the fundamental mechanisms of brain function is the first step towards producing appropriate therapeutic treatments for dementia, depression, schizophrenia and other disorders. Research within the joint laboratory has already attracted $3.25m in grant, fellowship and matching funding.