

UNIVERSITY RESEARCH:

policy considerations to drive Australia's competitiveness



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Executive summary

Universities are integral to Australia's research effort and provide the foundation of skills and knowledge required for the nation's long-term success. Research and innovation have been consistently identified as essential ingredients for improving productivity and quality of life. If Australia is to continue to compete internationally, we must critically look at our performance and identify ways of strengthening all elements of the system.

Australia's research performance compares well internationally, both in productivity and research excellence. In terms of academic impact, there are clear areas of strength across the breadth of disciplines and Australia's researchers are highly regarded. There is, however, room for improvement, especially relative to the best-performing nations. Knowledge exchange and the ease of translation of research into the broader economy and community are Australia's main areas requiring substantial attention.

An examination of the countries chosen for comparison—Switzerland, Denmark, the Netherlands, Singapore, South Korea, Malaysia, the United Kingdom and Canada—brings to light several similarities in their approaches that should be considered for Australia's future approach:

- Long-term strategies and plans have been implemented, including targets and priority areas, accompanied by significant and ongoing support.
- The strategies focus on areas of national interest and comparative advantage and take into account the country's industrial structure and location.
- The unique role of universities is recognised, as is the need to support a balance of investigator-led and mission-led research.

If we are to improve Australia's performance and achieve the broader aims for research, a range of matters needs to be considered by the university sector and government:

- Australia needs a long-term plan that outlines national priority areas and secures ongoing and reliable support for the fundamentals of the research system.
- Reward and recognition mechanisms at the researcher and university levels should be critically examined.
- We need to support a balance of basic and applied and investigator-led and mission-led research, maintaining the strong focus on research excellence.
- Australia must increase its efforts in both domestic and international collaboration, especially in the priority areas identified.
- The career path for researchers in all sectors must be improved. We must ensure our best and brightest can move freely between industry and academia.
- Holistic, ongoing funding for national research infrastructure is imperative.
- A transactional view of university–industry collaboration will not deliver the deep and productive relationships required to improve the translation of research.

In view of accelerating investment in research and innovation by our Asian neighbours and traditional competitors, Australia could be close to the proverbial ‘tipping point’, whereby we are not able to achieve our goal of a high-wage, high-growth economy.

A national strategy that addresses all facets of the system, targets both supply and demand, and includes long-term financial commitments is needed in order to bring about cultural change and improve Australia’s research and innovation performance.

Universities Australia has prepared this paper to inform current and future debate about university research and its role in driving Australia’s competitiveness.

I Introduction

Countries around the world have recognised they cannot be complacent if they are to compete and prosper in a rapidly changing global economy. Our competitors are introducing explicit strategies for supporting research and innovation as prime drivers of economic and social prosperity. Despite difficult economic times, many countries are nevertheless continuing to increase their investment. Central to their strategies is the aim of creating a ‘knowledge economy’, in which research organisations, business and government work together to create the industries of the future and improve citizens’ living standards.

This recognition is based on a clear understanding that investment in research is fundamental to future progress. For example, the European Commission report on the Horizon 2020 initiative states:

A wealth of evidence demonstrates the crucial role that research and innovation play in the sustainable growth of productivity and thus in economic growth. Modern economic theory unanimously recognises that research and innovation are prerequisites for the creation of more and better jobs, for productivity growth and competitiveness, and for structural economic growth. (2013, p. 16)

The OECD’s work has consistently highlighted the role of research and innovation in helping countries achieve their economic and societal goals:

Innovation drives growth and is essential for addressing global and social challenges ... it holds the key, both in advanced and emerging economies, to employment generation and enhanced productivity growth through knowledge creation and its subsequent application and diffusion. (2010, p. 2)

It is also evident that prosperity depends on investing in research in the broadest sense—not just in areas that are expected to lead to short-term gains:

Knowledge generated by research is the basis of sustainable social development ... when countries lose their base for academic excellence—through outdated policies, neglected institutions, the exodus of their best graduates or woefully inadequate investment in research—their competitiveness in the global knowledge society will dwindle and eventually disappear. (Kearney 2009, pp. 10–14)

Recent work in Australia is building on this international evidence. The Australian Council of Learned Academies report released in 2014 shows there is strong evidence that research, science and technology lead to greater productivity (Bell et al. 2014). The Business Council of Australia has also noted that investment in and funding of basic research contribute to long-run innovation outcomes and that Australia needs to ensure that it continues to invest in expanding its stock of knowledge (BCA 2013). In a more recent discussion paper the BCA advances the following proposition:

Governments need to take a more purposeful approach to enabling and fostering the competitiveness of industry sectors by putting in place the infrastructure that is needed

to foster innovation—this is about making sure that the important policy domains that are critical to innovation, such as education, research and development, physical and technological infrastructure, and regulatory settings, are in place and coordinated. (BCA 2014, p. 6)

Beyond driving productivity growth, research is vital to many other aspects of Australia's prosperity and living standards. Health and medical research is delivering better outcomes for patients and more efficient health care services. Environmental research is leading to better management of Australia's abundant natural resources. Agricultural research is producing nutritionally improved foods and greater food safety. Research in the social sciences is resulting in more effective government policies and improving our understanding of community attitudes and behaviours. These are just a sample of the ways research benefits all Australians.

Australia has demonstrated its understanding of the importance of investment in research and development and has improved its performance in many areas. The Australian Government has made a commitment to building a more diverse, world-class economy based on five pillars—manufacturing innovation, agricultural exports, advanced services, world-class education and research, and mining exports—in order to make the most of our comparative advantages in international markets. All five pillars rely on the foundation afforded by science and research.

During a recent visit to the Peter MacCallum Cancer Centre, the Prime Minister stated, 'This is a government which is dedicated to science, which is devoted to research, and wants to massively increase Australia's research effort' (Abbott 2014). The Australian Government's *Industry Innovation and Competitiveness Agenda*, released in October 2014, highlights the role of science and research in improving Australia's global competitiveness (Australian Government 2014a). The subsequent consultation paper argues that better translation of research into commercial outcomes will help drive innovation in Australia, grow successful Australian businesses and research capacity, and boost productivity and exports (Department of Education and Department of Industry 2014).

To achieve these ambitions, there are issues that need attention. We must have a coordinated, strategic and long-term approach to our investment, building on our strengths and redressing our weaknesses. As Ben Bernanke, former Chairman of the US Federal Reserve, has highlighted:

... However it is channelled, government support for innovation and R&D will be more effective if it is thought of as a long-run investment. Gestation lags from basic research to commercial application to the ultimate economic benefits can be very long. The Internet revolution of the 1990s was based on scientific investments made in the 1970s and 1980s. And today's widespread commercialization of biotechnology was based, in part, on key research findings developed in the 1950s. Thus, governments that choose to provide support for R&D are likely to get better results if that support is stable, avoiding a pattern of feast or famine. (Bernanke 2011)

Australia's universities are fundamental to our research effort. As knowledge institutions, they provide the skilled graduates and the wellspring of new ideas we need. Our international research reputation attracts the best and brightest to study and work in Australia, driving our third largest export industry (DFAT 2014). Universities have a unique role, combining research and education to create the knowledge workers that are fundamental to an expanding economy.

Australia's universities know, however, that there are areas in need of improvement at the system and institutional levels. The environment for universities throughout the world is changing, and the level of internationalisation and competition will continue to increase. If they are to maintain their relevance, universities must critically examine their role and purpose so that they can achieve the desired outcomes for Australia and secure their central role in ensuring Australia's future competitiveness.

A range of important policy processes currently under way or expected to begin in the months ahead will consider many aspects of the Australian research system, including funding, research training, research infrastructure and collaborative research. A clear focus for the Australian

Government is ensuring that Australia's research effort is addressing key national priorities and supporting the translation of research into commercial outcomes.

In order to assist the associated discussions and to provide context for the matters to be debated, Universities Australia has carried out an analysis of the current research system and its performance, with particular reference to a number of 'comparator' countries. The countries were chosen for a variety of reasons, among them to highlight strong research performers and those that are catching up. The various structures, strategies and policy instruments are considered for each of the comparator countries, along with indicators of their performance.

Drawing on this information and analysis, the final chapter of this report presents a range of policy considerations for the university research sector. These considerations cover the principal aspects of Australia's university research system and point to possible areas for change to improve our performance and increase our sector's contribution to Australia's prosperity.

2

Australia's research system

The research system in Australia consists of many different contributors with different but complementary roles. The interrelationships and dependencies between these contributors are complex but are important to an understanding of the performance of the system as a whole.

This chapter provides a brief description of the system and follows this with detailed information about its primary contributors:

- universities
- government research organisations
- businesses
- collaborative structures and other research organisations.

2.1 The system in brief

Australia's university system is relatively small but diverse. There are 37 public, three private and two overseas universities. All these universities are engaged in research, although research intensity varies throughout the sector.

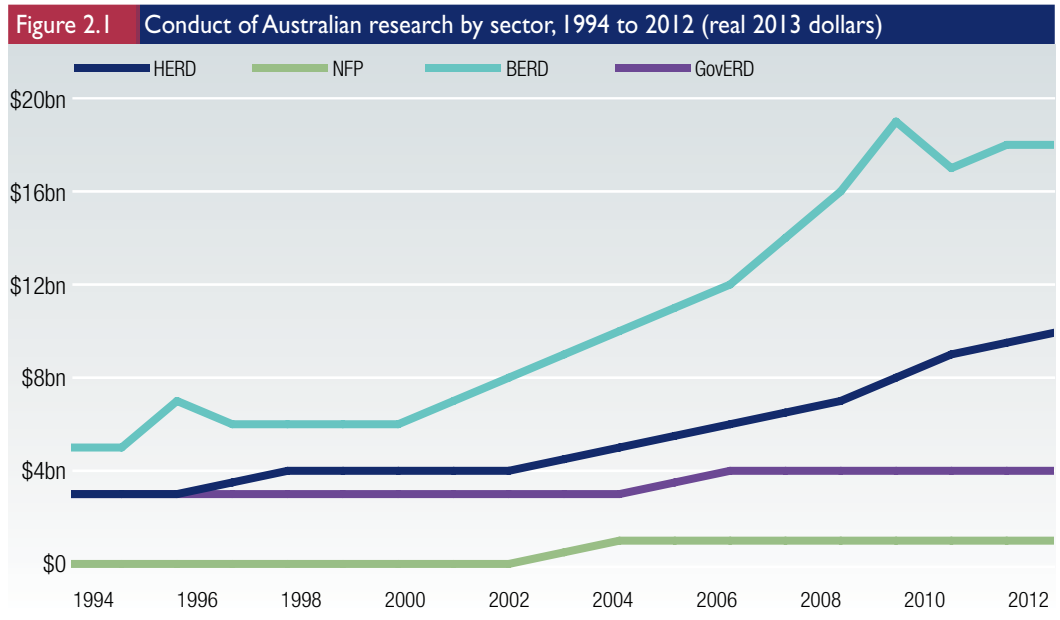
Policy responsibility for research and innovation lies principally with two federal ministries—education and industry. The Minister for Education is responsible for research policy in relation to universities, research infrastructure, and research grants and fellowships, including the Australian Research Council. The Minister for Industry is responsible for science policy, coordination of science research policy, and business research and commercialisation.

The main competitive grant programs are administered by the Australian Research Council and the National Health and Medical Research Council, the latter being an agency of the Department of Health. There are a number of government research organisations; the two largest are the Commonwealth Scientific and Industrial Research Organisation and the Defence Science and Technology Organisation.

In terms of expenditure, business is responsible for the greatest amount of research and development in Australia. To put this in context, the Australian economy is dominated by the services sector and there are strong agricultural, mining and manufacturing sectors. The mining, manufacturing and financial services sectors are the top-ranked investors in R&D. The majority of Australian firms are small to medium enterprises, or SMEs.

2.2 Expenditure by the various sectors

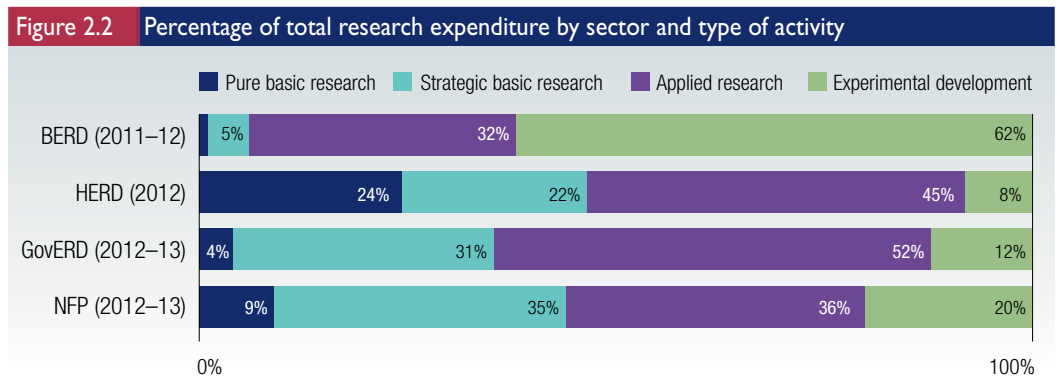
The overall level of research effort in Australia, as shown through expenditure in real terms, has increased considerably in the past 20 years. Comparing sectors, some trends are apparent (see Figure 2.1). Business expenditure, or BERD, has grown the most; higher education expenditure, or HERD, has also increased but less rapidly. In comparison, government expenditure, GovERD, has grown only slightly. Not-for-profit expenditure has increased but still accounts for only a small proportion of total expenditure.



Source: ABS (2013, 2014a, 2014b)

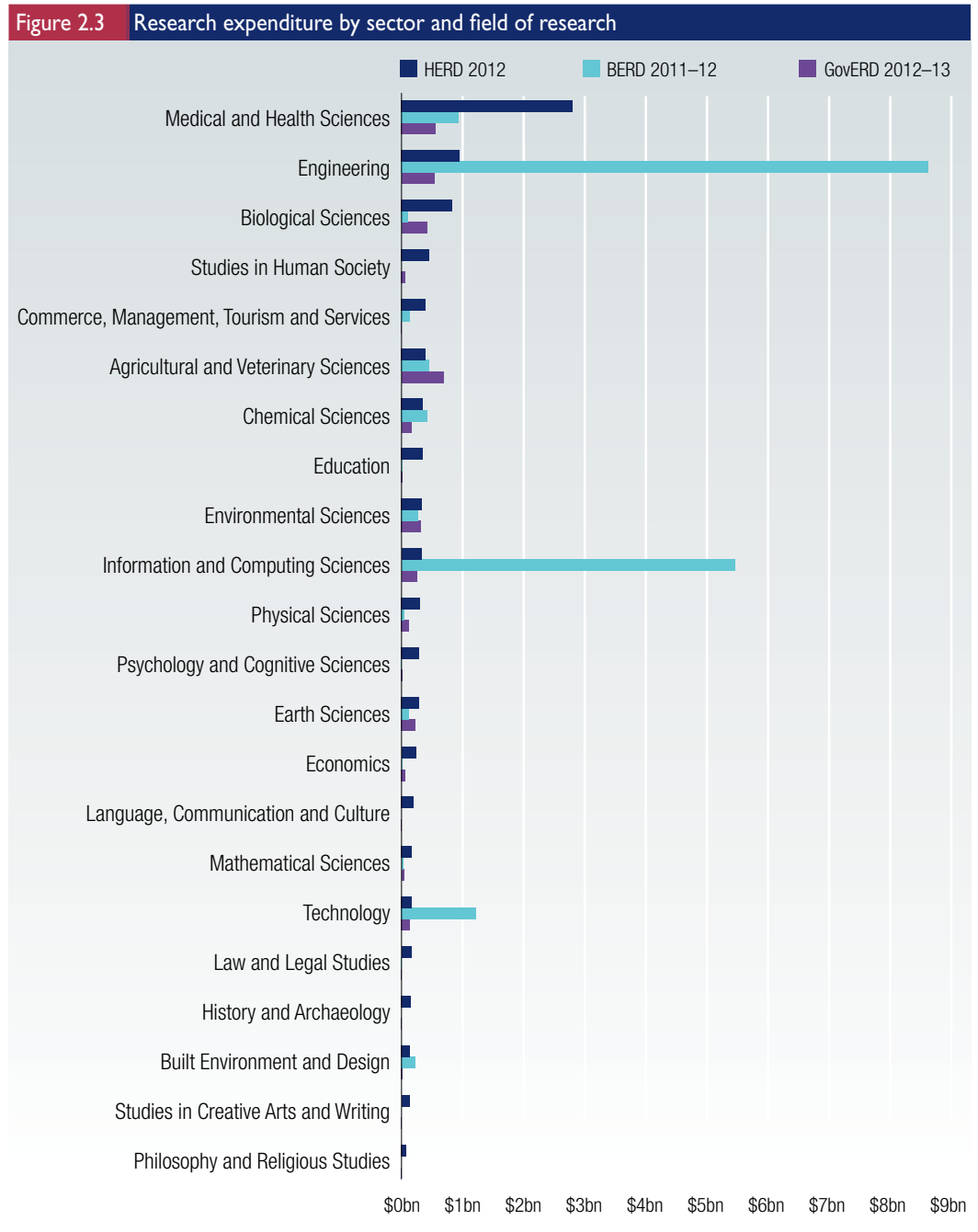
Australia's gross expenditure on research and development, or GERD, as a proportion of GDP increased until 2008, to a peak of 2.25 per cent, but then declined to 2.19 per cent in 2010 (OECD 2014). The research workforce has also grown considerably in the past 20 years. The population of researchers grew by 104 per cent from 1992–93 to 2011–12; growth was even stronger in the higher education sector, at 134 per cent (ABS 2013, 2014a, 2014b). It is thus evident that research intensity in Australia has increased in both absolute and relative terms.

In terms of the type of research, each of the sectors has a distinct profile (see Figure 2.2). As is to be expected, the business sector focuses on applied research and experimental development, with only 6 per cent of research in 2011–12 classified as pure or strategic basic research. In keeping with its role in the research system, the higher education sector performs the greatest proportion of pure basic research. Comparing sectors has become more complicated since the decision of the Australian Bureau of Statistics to cease providing an all-sector summary of expenditure on research and development.



Source: ABS (2013, 2014a, 2014b)

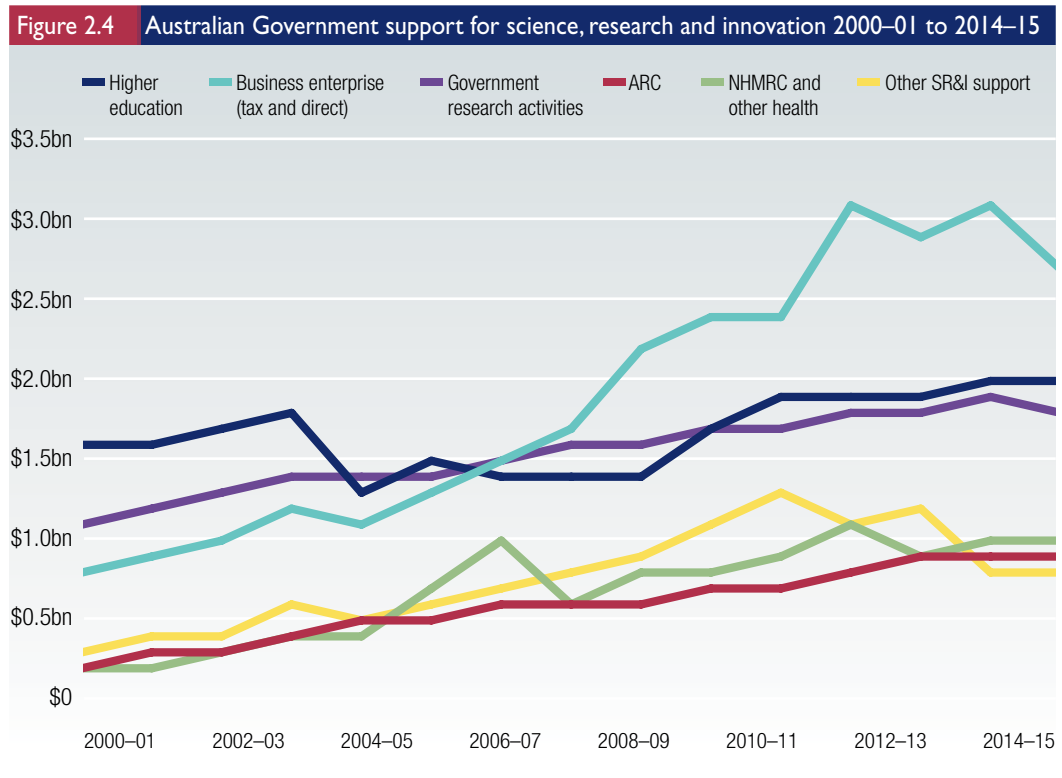
Expenditure by field of research offers another interesting picture of the profile of research effort in Australia (see Figure 2.3). Medical and Health Sciences accounts for the largest proportion of expenditure for the higher education sector, at 29 per cent, while Engineering and Information and Computing Sciences dominate business expenditure, at 47 and 30 per cent respectively. This could be indicative of a mismatch in Australia’s research effort but more probably reflects the differing roles of universities and business.



Source: ABS (2013, 2014a, 2014b)

2.3 Australian Government support

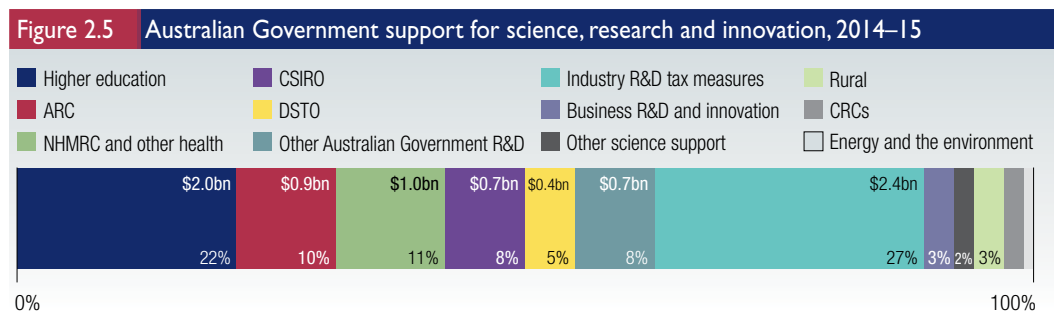
The Australian Government provides a range of support for science, research and innovation—not only for the conduct of research but also for the research workforce, research infrastructure, and domestic and international collaboration. The Science, Research and Innovation Budget Tables are a valuable resource for tracking this investment over time. Support for business research and development has grown considerably—by more than 250 per cent between 2000–01 and 2014–15—despite a dip in the R&D Tax Incentive claimed following the global financial crisis. Higher education sector support, excluding the NHMRC and the ARC, grew by only 28 per cent in the same period.



Source: Australian Government (2014)

It is estimated that in 2014–15 the Australian Government will invest \$9.19 billion in science, research and innovation, broadly as follows:

- 30 per cent on business enterprise support (tax incentive and direct)
- 21 per cent on performance-based block funding for universities
- 20 per cent on competitive grant funding through the ARC and the NHMRC
- 20 per cent on Australian Government research activities
- 9 per cent on other sectors and other science, research and innovation support (see Figure 2.5).



Source: Australian Government (2014)

2.4 Sector characteristics

2.4.1 Universities

Australia's university sector has evolved and grown considerably from a few state-based institutions and their offshoots to the 42 institutions today. The most noteworthy change in the sector followed the so-called Dawkins reforms of the early 1990s, when Colleges of Advanced Education were transformed, both physically and conceptually, into universities. With those changes came the requirement that all universities conduct research, something that is uncommon internationally.

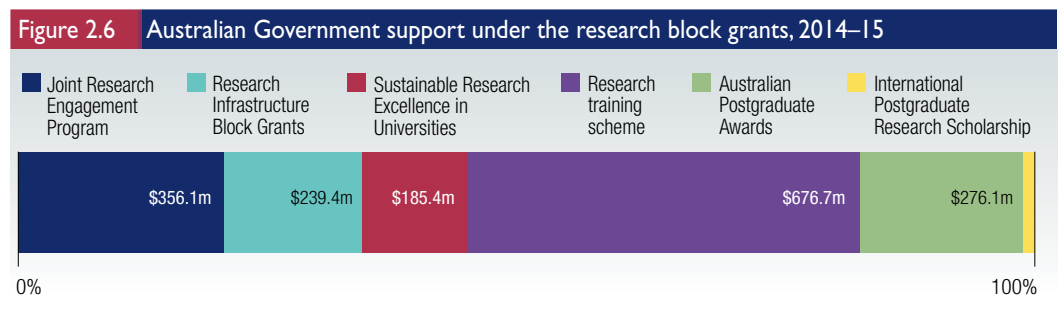
Universities have a particular and essential role in the research system. They perform the majority of the basic research and provide a broad base of expertise across the range of research disciplines. Such a base is essential if Australia is to be research active itself and to make use of the knowledge developed internationally for local benefit. Advanced industrial countries need their own well-developed basic research capability in order to benefit from the knowledge generated by others and to sustain technological development (Salter & Martin 2001).

The provision of skilled research graduates is another defining feature of the role of the higher education sector. Apart from providing the next generation of researchers, these graduates bring strong problem-solving and critical-thinking skills to their places of work.

Australia has a dual support system for university research—direct and indirect funding. The bulk of the direct competitive funding is provided through the ARC and the NHMRC.

The research block grants provide the indirect funding to support university research and research training (see Figure 2.6).¹ Funding amounts under each block grant scheme are calculated using a mix of indicators—research income in four categories, higher degree student load and completions, and publication outputs (Department of Education 2014e). The four categories of research income are as follows:

- Category 1: Australian competitive grants (schemes listed on the Australian Competitive Grants Register, including the ARC and the NHMRC)
- Category 2: Other public sector research income
- Category 3: Industry and other research income
- Category 4: Cooperative Research Centre income.

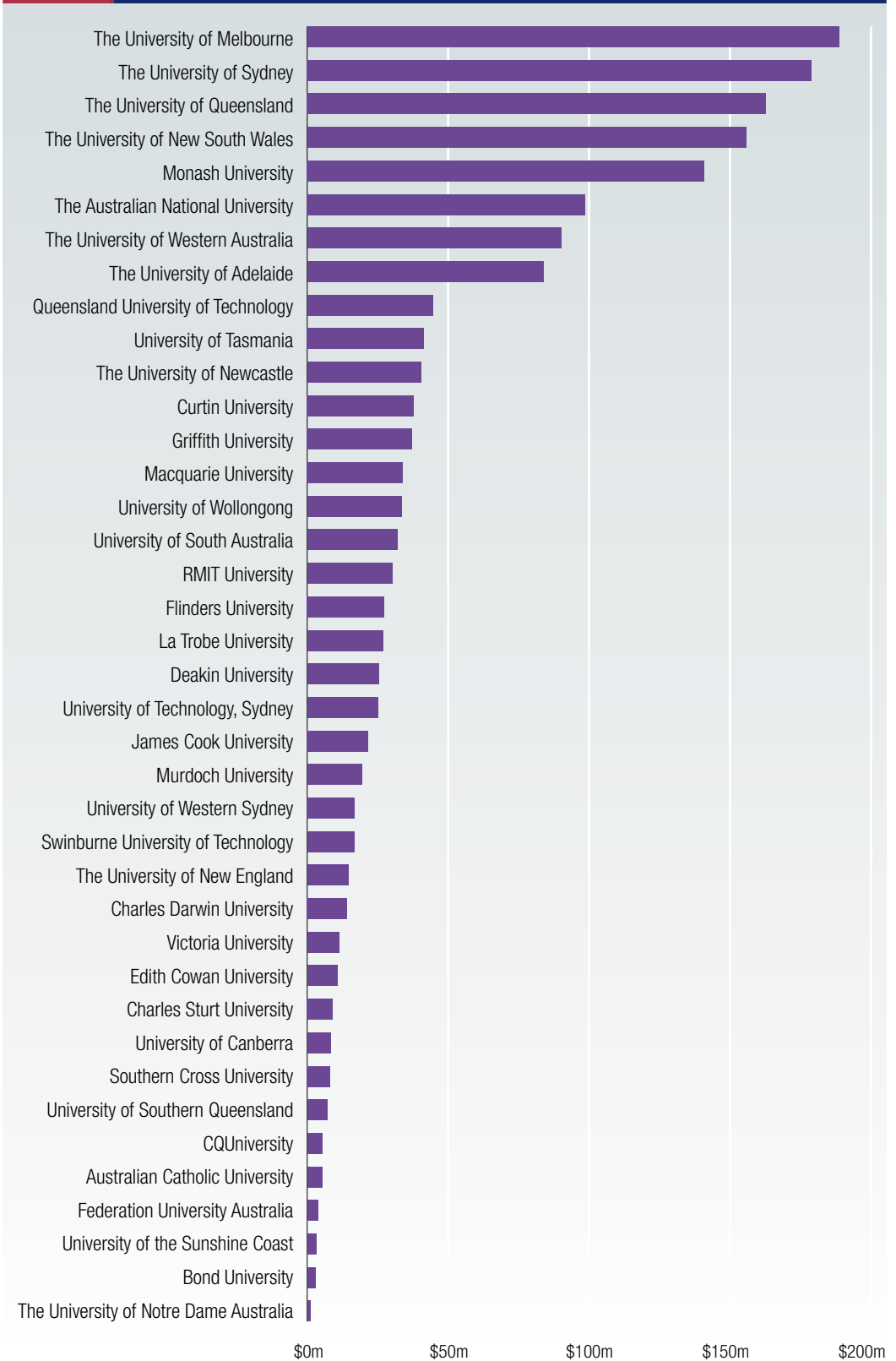


Source: Australian Government (2014).

The considerable diversity in the research profile of Australia's universities can be seen in the amount of research block grant funding allocated to each university (see Figure 2.7). Each university's proportion of the total funding is relatively unchanged from 2010 to 2014.

¹ Appendix A provides further information about the research block grants.

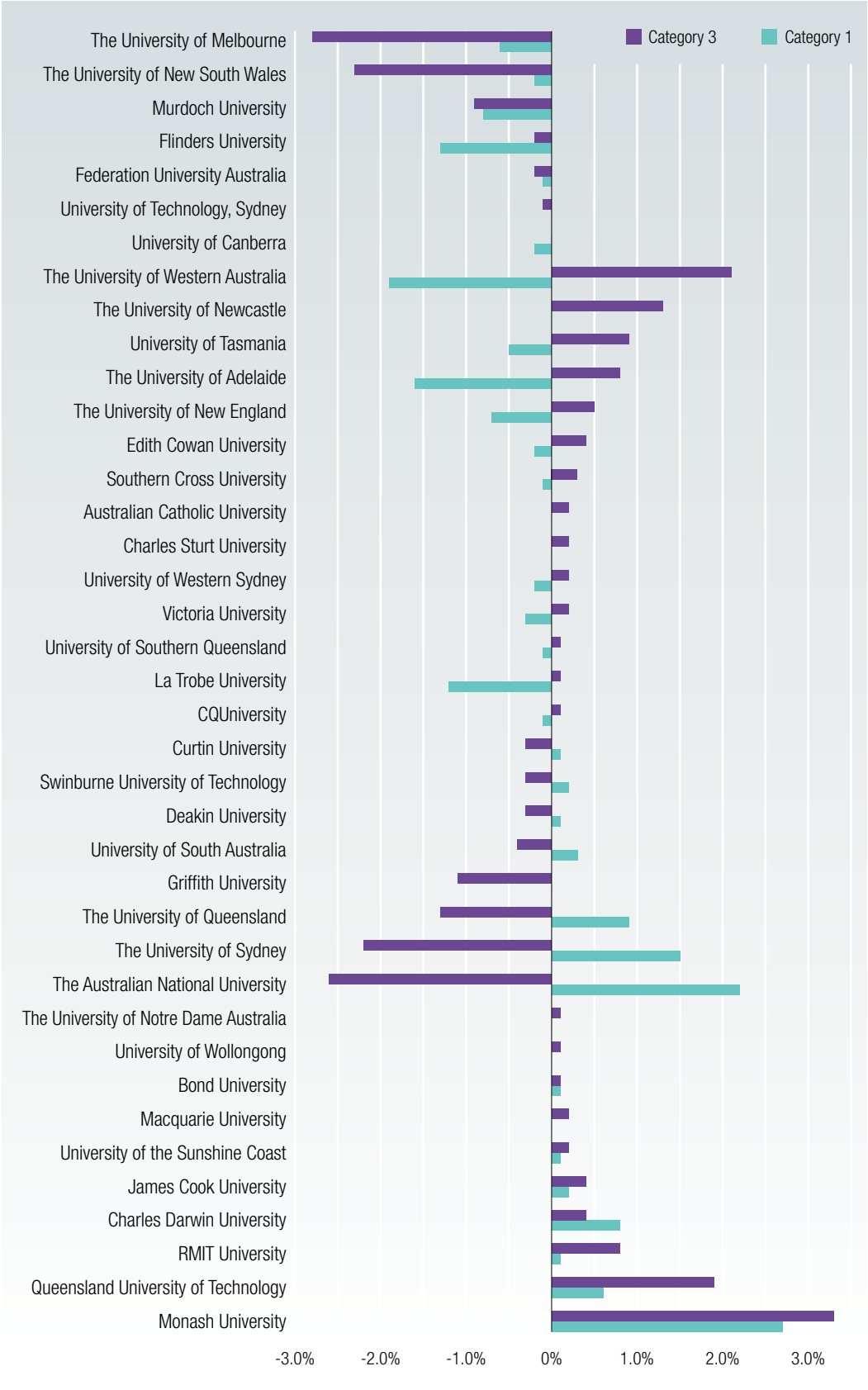
Figure 2.7 Research block grant allocations



Source: Department of Education (2014d)

Despite the perception of uniformity conveyed by the current requirement for universities to engage in both teaching and research, there is considerable diversity in universities' strategic focus. The change in the levels of Category 3 and Category 1 research income from 2001 to 2012 (as a percentage of the total income for these categories) provides an indication of the differing directions taken in the sector (see Figure 2.8).

Figure 2.8 Change in Category 3 and Category 1 income as a percentage of total income for each category, 2001 to 2012²



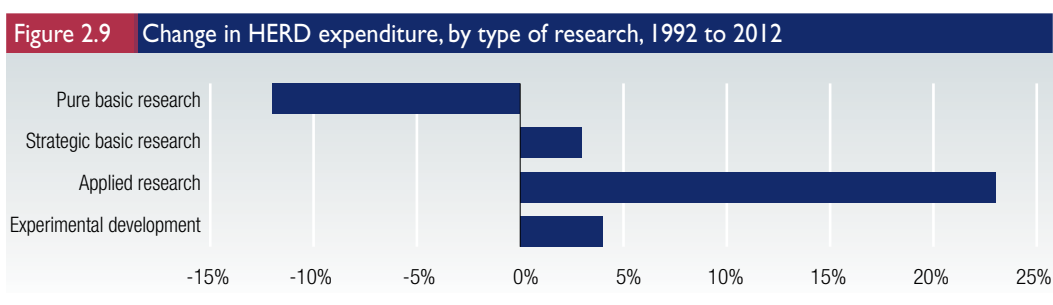
Source: Department of Education (2014b).

2 If a university's share of total income in a category rises from 5 to 6 per cent, it is shown as a +1 per cent change. This shows changes in the share of the total, rather than simply growth by university.

The expenditure on research by the higher education sector is significantly greater than the direct research funding the sector receives from the Australian Government. For 2012 HERD was \$9.6 billion, and the majority of this came from General University Funds. GUF includes funding from the Australian Government that is not specifically targeted at research, including under the Commonwealth Grants Scheme, along with income such as non-research specific donations and investment income.

The proportion of HERD obtained from GUF decreased between 1994 and 2012, from 64 to 56 per cent. Funding from business peaked in 2006, at 6.1 per cent, then declined to 4.1 per cent in 2012. Other Australian Government support, which includes the research block grants, increased from 7 per cent in 1994 to 15 per cent in 2012 (ABS 2013, 2014a, 2014b).

As Figure 2.9 shows, universities have also changed their focus in the past 10 years to increase the proportion of expenditure on applied research as opposed to pure basic research. The reduction in the proportion of expenditure on basic research has been noted as a concern since basic research is essential to maintaining a world-class research and innovation capability. It also raises the question of why the increased expenditure on applied research has not substantially improved university–industry collaboration.



Source: ABS (2013, 2014a, 2014b)

The Medical and Health Sciences field of research accounted for the highest level of HERD for 2012 (see Figure 2.3). As a proportion of total HERD, expenditure on this field of research increased more than expenditure on any other field of research between 1992 and 2012, from 19 to 29 per cent.

2.4.2 Government research organisations

Beyond the universities, publicly funded research is also conducted in a range of government research organisations, which have varying roles and areas of interest. These organisations conduct long-term, mission-led research in many priority areas for government and the economy. A number of the organisations also play an important part in the research system as hosts of national facilities and collections and in fostering enduring international relationships.

The largest such organisation is CSIRO, one of the most diverse research agencies in the world, with more than 50 sites in Australia and overseas. CSIRO recently announced a restructure of its operations. From July 2014 it has three lines of business:

- national facilities and collections
- impact science—including a new flagship portfolio
- services—including education, publishing, infrastructure technologies, SME engagement and CSIRO Futures.

These changes are designed to differentiate CSIRO as a multidisciplinary applied research organisation and boost its position as a provider of innovation services to industry, including Australian SMEs (Clark 2014). The nine new flagships are agricultural productivity, future manufacturing, digital productivity and services, energy, mineral resources, oceans and atmosphere, food and nutrition, land and water, and biosecurity.

CSIRO's revenue in 2012–13 was \$1.2 billion, 18 per cent of this coming from the private sector and 20 per cent from international sources (CSIRO 2013). Direct Australian Government

support for research activities within CSIRO amounted to \$734 million in 2012–13 (Australian Government 2014b).

The other large public research organisations are the Defence Science and Technology Organisation, DSTO, and the Australian Nuclear Science and Technology Organisation, ANSTO, with Australian Government investment in 2012–13 of \$434 million and \$229 million respectively. DSTO is the Australian Government's lead agency charged with applying science and technology to protect and defend Australia and its national interests. ANSTO is Australia's national nuclear research and development organisation; it produces and uses radioisotopes, isotopic techniques and nuclear radiation for medicine, science, industry, commerce and agriculture.

Other government research organisations are Geoscience Australia, the Australian Antarctic Division, the Australian Institute of Marine Science, or AIMS, and the research activities of the Bureau of Meteorology. There is also the Australian Institute of Aboriginal and Torres Strait Islander Studies as well as the Australian Centre for International Agricultural Research, which operates as part of the Australian aid program.

Savings and efficiency cuts to ANSTO, AIMS and CSIRO since the 2013 election amount to a reduction of \$168.7 million over four years.

Government (Commonwealth and state and territory) expenditure on research and development for 2012 was \$3.5 billion. It should be noted that this figure does not include financial transfers from government to other sectors to support their conduct of research, such as the funding provided to the higher education sector.

As Figure 2.1 shows, GovERD has risen slowly compared with BERD and HERD, increasing by only 15 per cent from 1992 to 2012. In fact, in real terms GovERD is lower than it was in 2006. GovERD by field of research has a very different profile from that of HERD and BERD, with Agricultural and Veterinary Sciences being the field of greatest expenditure for 2012–13 (see Figure 2.3).

2.4.3 Businesses

Businesses account for the highest proportion of research expenditure in Australia, although the expenditure occurs within a much narrower range of areas than is the case for universities and government research organisations. As expected, business expenditure is heavily skewed to applied research and experimental development (see Figure 2.2).

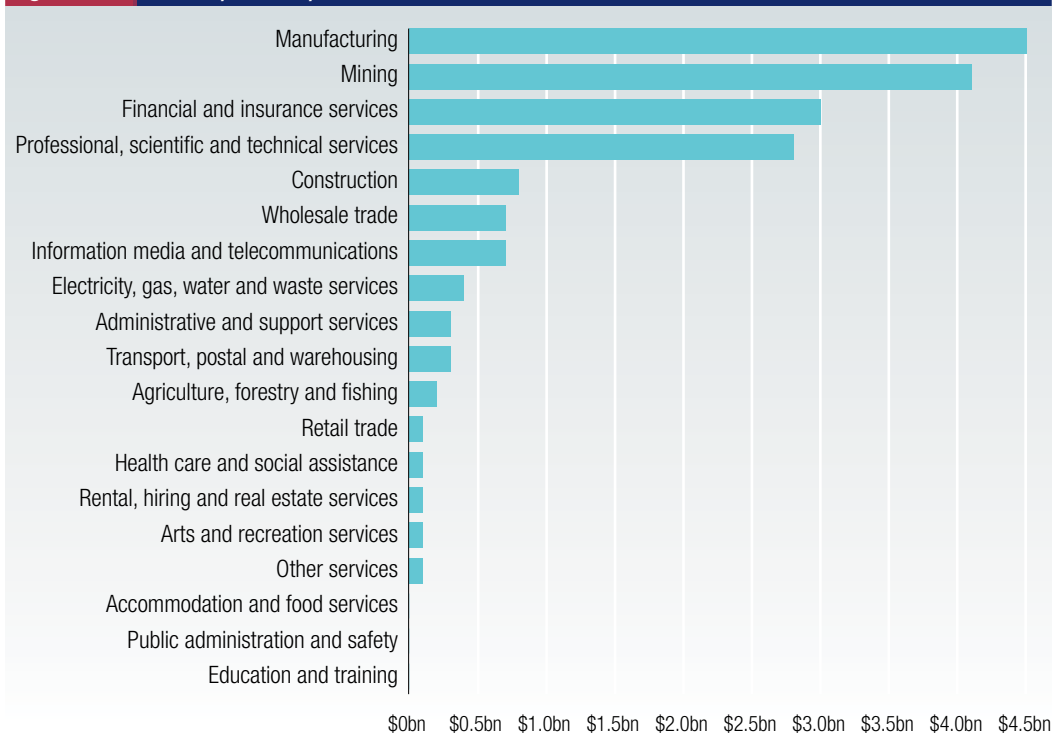
Australian Government support for business research is primarily provided through the R&D Tax Incentive (\$2.4 billion in 2014–15), which is a broad-based entitlement program that helps businesses offset some of the costs of doing R&D. It is currently open to firms of all sizes in all sectors, but it has more generous arrangements for SMEs.

As part of the 2014–15 Federal Budget, the Australian Government reduced the rate of refundable and non-refundable offsets to all companies by 1.5 percentage points, effective from 1 July 2014. The preceding government's decision to deny access to the R&D Tax Incentive for large companies with an income of \$20 billion or more has also been upheld.

Additionally, several programs that support innovation in industry were abolished—among them Commercialisation Australia, the Innovation Investment Fund and the Industry Innovation Precincts—allowing for savings of \$845.6 million over five years. These programs were in part replaced by the new Entrepreneurs' Infrastructure Programme, with funding of \$484.2 million over five years from 2013–14. This new initiative combines some aspects of the previous programs, albeit with a reduced amount of funding.

The Manufacturing and Mining sectors expended the most in 2011–12 on research and development; they were followed by the Financial and Insurance Services and the Professional, Scientific and Technical Services sectors (see Figure 2.10).

Figure 2.10 BERD, by industry sector, 2011–12



Source: ABS (2013)

2.4.4 Collaborative structures and other research organisations

There is a range of other smaller organisations and structures in Australia’s research system; they are often collaborative and bring together partners to respond to a particular question or area of research. Australian Government funding for collaboration programs such as the Centres of Excellence and the Cooperative Research Centres is generally allocated on a competitive basis and over a longer term than is the case with project grants. This extended funding period is pivotal to the success of the collaborations, as is a degree of flexibility in the path chosen to achieve the stated goals.

The ARC Centres of Excellence support Australian researchers working on large-scale programs over longer periods, linking existing research strengths, building critical mass, and creating new capacity for interdisciplinary, collaborative approaches. The scheme began in 2002 and has supported 51 centres, 26 of which are currently receiving funding.

Each centre collaborates with partners from the university sector and other institutions world-wide, facilitating international knowledge transfer. The 12 centres funded in the 2014 round will receive a total of \$284.9 million; they cover areas such as advanced molecular imaging, mathematical and statistical frontiers of big data and electromaterials science.

The NHMRC also funds Centres of Research Excellence to support teams of researchers in pursuing collaborative research and developing capacity in clinical health, population health and health services research. The funding duration is five years.

The Cooperative Research Centres are end-user driven research partnerships between publicly funded researchers, business and the community. The CRC Program supports research collaborations in all disciplines and industry sectors and has a long history of developing solutions to address major challenges and improving the competitiveness of Australian industries.

The CRC Program has been a key feature of Australia’s system since it began in 1991, and 200 CRCs have received program funding of more than \$3.7 billion as well as \$11.7 billion in cash and in kind from participating organisations. There were 40 active CRCs in 2013–14, down

from 70 in 2006. The program has undergone a number of reviews, and another is currently in progress. In the 2014–15 Budget, it was announced that the 17th selection round would not proceed, and funding was reduced by \$80 million over the forward estimates.

The Rural Research and Development Corporations represent a different model of collaborative research. Today they are a mix of statutory and industry-owned companies. The government–industry partnership model that supports the RDCs has been operating for more than 20 years and now provides over \$470 million in annual R&D funds, including around \$247 million from industry and \$218 million from government in matching contributions.³

Fifteen rural RDCs cover virtually all agricultural industries, and they are a vital element in the success of Australia’s R&D effort. In the agriculture, fisheries and forestry sector, for example, R&D has helped Australian agriculture double its productivity in the past 25 years (Council of Rural Research and Development Corporations 2014).

The Collaborative Research Networks Program supports collaboration between smaller, regional and less research intensive universities and other higher education institutions in areas of common interest. It has been successful in improving the extent of collaboration between universities, as well as responding to wider national research and innovation needs.

The Medical Research Institutes constitute another category of research organisation in Australia. These organisations can be independent charities, university-based institutes, part of a hospital or other health service provider, or institutes arising from alliances between a hospital and a university. They number over 50 in Australia, and they have a distinct role in the health and medical research sector, providing a direct link between laboratory-based research and clinical practice.

Australia’s Medical Research Institutes have a combined annual turnover of more than \$1 billion. The majority of their funding comes from competitive grants for research projects (primarily from the NHMRC); the remainder comes largely through state government infrastructure support, competitive grants from foundations and trusts, commercialisation collaborations and contracts, and community donations (Australian Association of Medical Research Institutes 2014).

³ 2008–09 financial year figures.

3

Indicators of performance

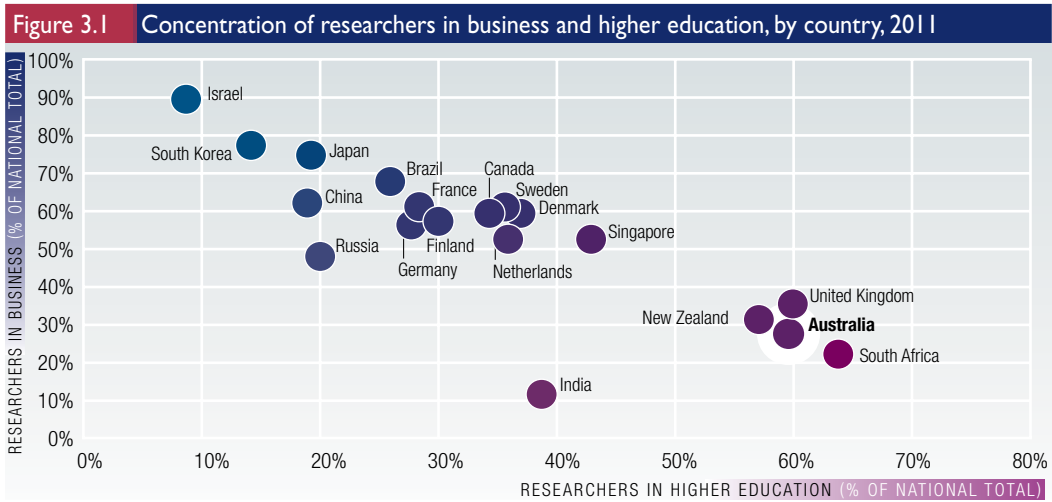
There is a range of different ways to consider the performance of Australia’s research system. The available data do not cover all aspects of the benefits sought from investment in research, but each data set does provide information that helps us understand the system’s strengths and weaknesses. This chapter uses a sample of the available indicators to assess the nation’s performance.

A major shortcoming for comparing the performance of research systems internationally is the lack of indicators of the transfer of knowledge and the benefits accruing from engagement with industry and the broader community. These outcomes are difficult to assess, but if they are not considered it is hard to develop a comprehensive picture of the role of research in driving greater productivity and wellbeing.

3.1 The research workforce

The structure of a nation’s research workforce has a significant influence on its research system. As Figure 3.1 shows, there is considerable diversity among nations in the balance of researchers in business and higher education. In contrast with many other nations, Australia’s researchers are concentrated in the higher education sector, although the balance between researchers in academia and industry has improved during the past decade.

Australia’s relatively low number of researchers in business has been identified as a factor contributing to the lack of collaboration between universities and industry. Research graduates employed in industry are an important conduit for increased links and sharing of expertise. Research skills enhance firms’ capacity to move up the value chain and differentiate products and services within tightly contested markets (DIISR 2011, p. 11).



Source: OECD (2014)

3.2 Excellence in Research for Australia

The Excellence in Research for Australia, or ERA, process conducted by the Australian Research Council in 2010 and 2012 evaluates the quality of the research performed in Australian universities against national and international benchmarks. The ratings are determined and moderated by committees of distinguished researchers drawn from Australia and overseas.

Among the indicators used are a range of metrics such as citation profiles, which are common to disciplines in the natural sciences, and peer review of a sample of research outputs, which is more broadly common in the humanities and social sciences. The ERA is a comprehensive collection, the data submitted covering all eligible researchers and their research outputs.

In 2010, 68 per cent of the 1738 units of evaluation⁴ assessed were rated at world standard or above. In 2012 this had increased to 80 per cent of the 1681 units assessed. The 2012 report also showed that 97 per cent of government funding in competitive grants was invested in research areas assessed as at or above world standard (Australian Research Council 2012).

Although the ERA process looks at university research, it also provides an indication of the system's performance as a whole because it includes outputs produced in collaboration with research partners such as government research organisations and industry.

The 2012 ERA found that Australia has 20 areas of national strength⁵:

- astronomical and space sciences
- cultural studies
- electrical and electronic engineering
- evolutionary biology
- historical studies
- immunology
- macromolecular and materials chemistry
- medical microbiology
- nursing
- plant biology
- clinical sciences
- ecology
- environmental science and management
- geology
- human movement and sports science
- law
- materials engineering
- medical physiology
- pharmacology and pharmaceutical sciences
- psychology.

Table 3.1 provides information on fields of research at the two-digit level assessed to be at world standard (represented by a score of 3) or above.

4 The unit of evaluation is broadly defined as the field of research within an institution based on the Australia and New Zealand Standard Classification (ANZSRC).

5 An ERA area of strength is defined as 10 or more Australian universities rated at world standard or higher, with four or more rated at well above world standard.

Table 3.1 ERA 2012 results at or above world standard, by institution and field of research

	Mathematical Sciences	Physical Sciences	Chemical Sciences	Earth Sciences	Environmental Sciences	Biological Sciences	Agricultural and Veterinary Sciences	Information and Computing Sciences	Engineering	Technology	Medical and Health Sciences	Built Environment and Design	Education	Economics	Commerce, Management, Tourism and Services	Studies in Human Society	Psychology and Cognitive Sciences	Law and Legal Studies	Studies in Creative Arts and Writing	Language, Communication and Culture	History and Archaeology	Philosophy and Religious Studies	
Australian Catholic University										3											3	3	
Bond University										4							3						
Charles Darwin University					4	3	4	3		3				3									
Charles Sturt University					4		3						3										3
CQUniversity	5						5			3													
Curtin University	3	3	3	5	3		3		3			3	3			3	3			3	3	3	3
Deakin University			5		3	3	3		4	4	5		3	3				3	3	3	3	3	3
Edith Cowan University						3					3										3		
Federation University Australia																							
Flinders University			3			3	3	3		4	3			3		3	3	3	3	3	3	3	3
Griffith University		3	3	3	3	3	4	3			3	3	3		3	4		4	4	3	4	3	
James Cook University	3	3	3	4	5	4	4		3									3		3	3		
La Trobe University		3			3	5	3	3			3			3	3	3		3	3	4	5	3	
Macquarie University		5	3	5	5	4		3	3			3	3	3		3	3	4	3	4	4	4	4
Monash University	3	4	5	3		4		4	5	5	5	3	4	5	4	3	3	5	4	4	5	5	
Murdoch University			3			3	4		3	5	4						3	3	3		3	3	
Queensland University of Technology	4	3	3	3	4	3		3	3	3	3	3	4	3	3		3	4	4	5			
RMIT University	3	3	3		3	3		3	4		4	4				3		3	3	4			
Southern Cross University				5		4	5													3			
Swinburne University of Technology		5	3					3	4			3					4			3	3		
The Australian National University	5	5	3	5	5	5	4	5	4		4			5	4	5	3	5	3	5	5	5	5
The University of Adelaide	4	5	4	4	4	3	4	4	3		5	3		4		3	3	4	5	3	3	4	
The University of Melbourne	4	4	4	4	4	3	4	5	5	5	5	4	4	5	5	4	5	5	4	5	5	4	
The University of New England	3			4	3	3	3									3	3	3	3	3	3	3	3
The University of New South Wales	4	3	5	4	3	4		4	4	4	5	4	3	4	5	4	5	5	5	4	5	4	
The University of Newcastle	3		3	5		4			5		4	3	3			3	5		3	3	3	3	
The University of Notre Dame Australia																							
The University of Queensland	4	5	5	3	4	5	4	4	5	5	5	3	5	4	4	4	4	4	4	4	5	4	4
The University of Sydney	5	4	4	4	4	4	5	4	5	4	5	3	4	4	4	4	5	5	4	5	5	5	
The University of Western Australia	3	5	3	4	4	4	3	3	4		5	3	3	4	4	3	4	3	4	4	4	3	
University of Canberra			3		3	3										3				3			
University of South Australia	4		5		4			3	4		3	3		3	3	3	3		3	3			
University of Southern Queensland	3	3					3																
University of Tasmania	3	4	4	4	3	4	4				3					3		4	3	3	4	3	
University of Technology, Sydney	3	3	3		5	3	5	3	3		3	3	3	5	3	3		4	3	4	3		
University of the Sunshine Coast						3	4																
University of Western Sydney	4		3		3	4	3		3		3		3			3		3	4	4	3	3	
University of Wollongong	4	3	5	4		3		3	4				3			3	3	4	4	3	4	3	
Victoria University	3								3		3								3	3			

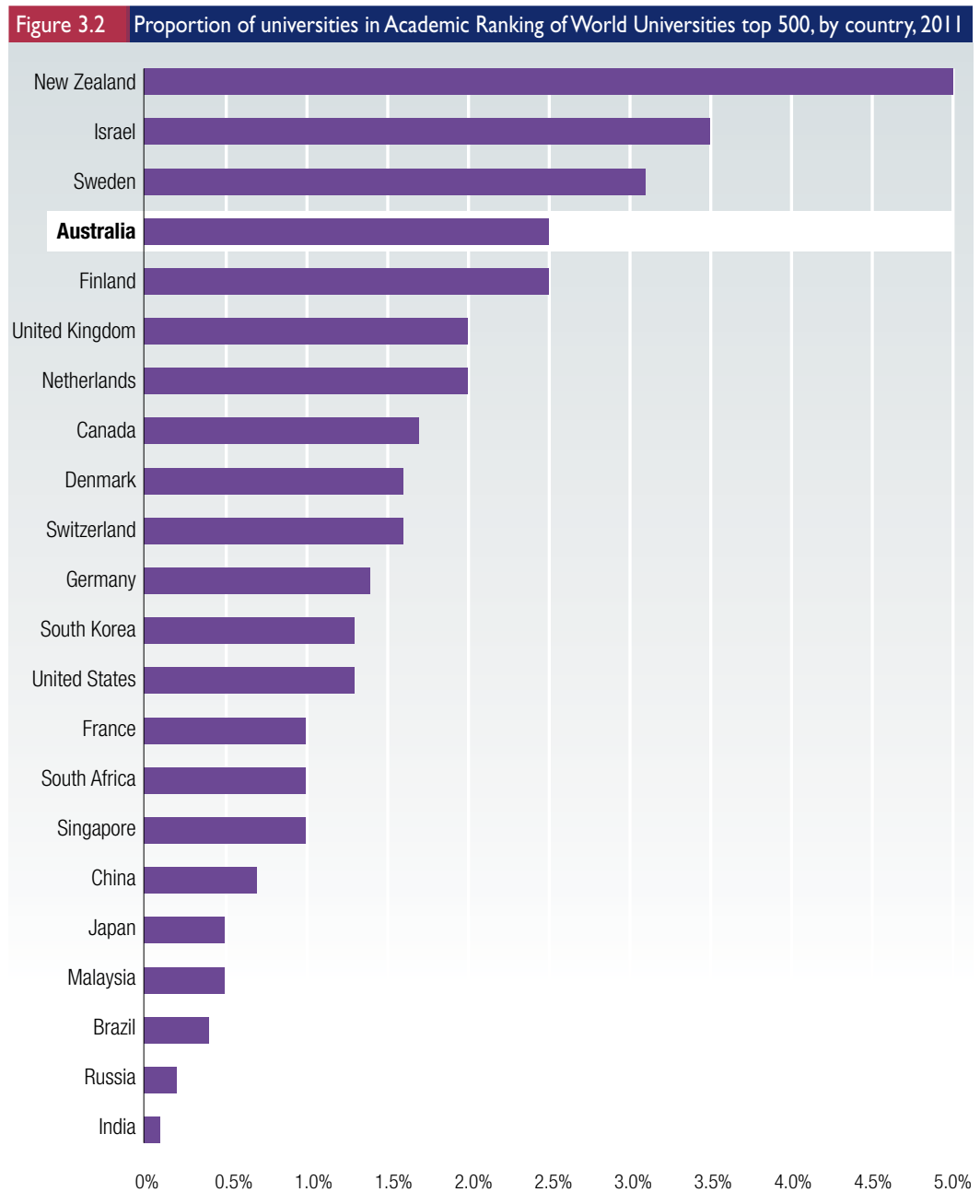
Source: Australian Research Council (2012)

3.3 University ranking

Research performance is a principal input for the most commonly used international university ranking systems and is generally measured through citations, publication in significant journals, and prizes, such as the Nobel Prize and the Fields Medal.

The Academic Ranking of World Universities can be used to compare Australia’s university research system as a whole internationally. As Figure 3.2 shows, once normalised for GDP Australia has the fourth highest proportion of the world’s top universities.

An issue often raised in relation to the currently available international ranking systems concerns the focus on research performance, which is but one aspect of institutional quality. Other important aspects of a university’s mission—such as teaching and learning and community and industry engagement—are not well represented in the current approaches.



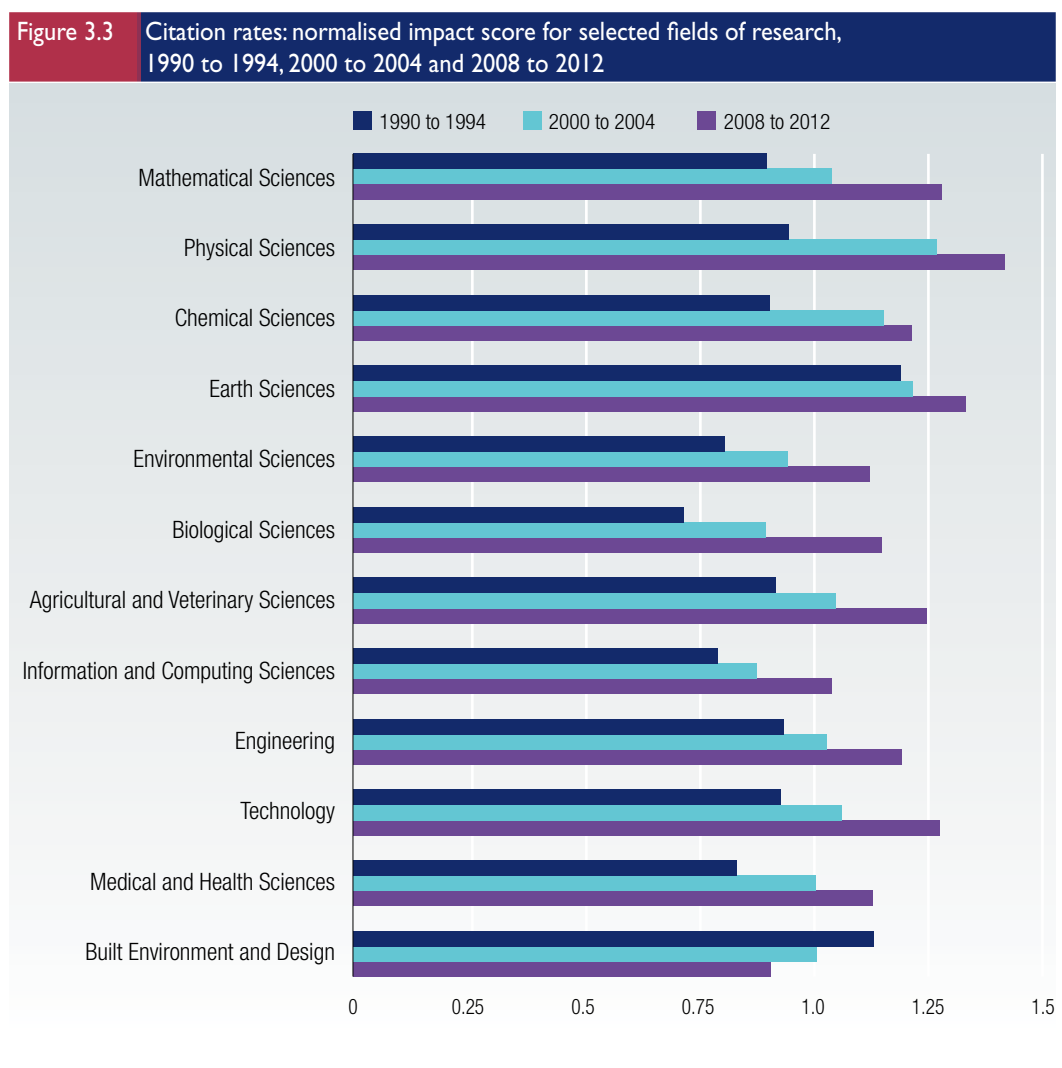
Note: Ranking normalised by GDP
Source: Shanghai Jiao Tong University (2014).

3.4 Academic impact

The Web of Science provides one of the most robust data sets from which to draw some conclusions about Australia's research performance. However, it must be noted that the Web of Science has limited coverage of journals, books, conference papers and other publications in the social sciences and humanities.

Australia's contribution to the total number of scientific publications in the world has increased in the past decade. In 2004 Australia produced 2.4 per cent of the world's publications; for 2011 the figure was 2.8 per cent. There has also been an increase in our performance in a number of academic impact indicators. In 2004, 0.91 per cent of our publications were highly cited; in 2013 the figure was 1.12 per cent. Similarly, our percentage of publications in the world's top 10 per cent increased, from 8.63 per cent in 2004 to 12.14 per cent in 2013 (Thomson Reuters 2014).

Figure 3.3 shows that citation rates for Australian publications have been increasing in almost all fields of research in recent years when compared with the world average (represented by a value of 1).



Source: Data analysis by LH Martin based on Thomson Reuters (2014).

As Australia's Chief Scientist has noted, however, these encouraging data on our research outputs relative to the world average need to be considered carefully. When comparisons of national citation rates generally and in different disciplines are made against a smaller range of countries with which Australia collaborates and competes (such as those in Europe and North America), Australia ranks towards the lower end of that scale (Office of the Chief Scientist 2014a).

3.5 International collaboration

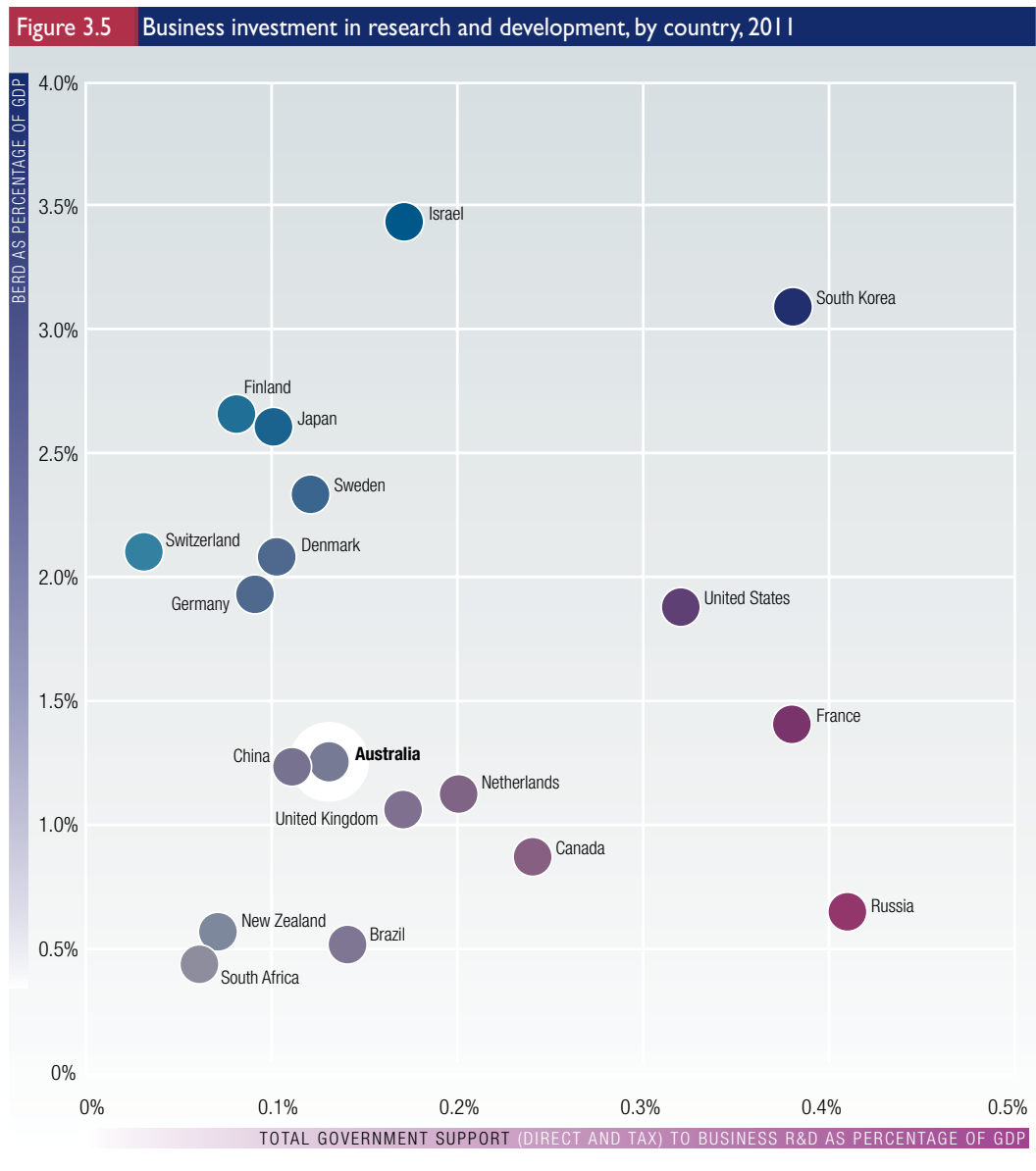
It is well recognised that collaborating with other countries is an important contributor to a nation's research performance. Although Australia is geographically isolated, our rate of international collaboration is above that of the United Kingdom and the United States. Australia is, however, being outperformed by a number of nations (see Figure 3.4).



Source: Thomson Reuters (2014).

3.6 Business investment in research and development and development

Increasing business investment in research and development is seen as one of the key contributors to the transition to a knowledge-based economy. As Figure 3.5 shows, nations such as Israel, South Korea, Finland and Japan have much higher levels of BERD as a percentage of GDP than Australia. The level of government support for business research and development in Australia is also considerably lower than that in countries such as Russia, France, South Korea and the United States.

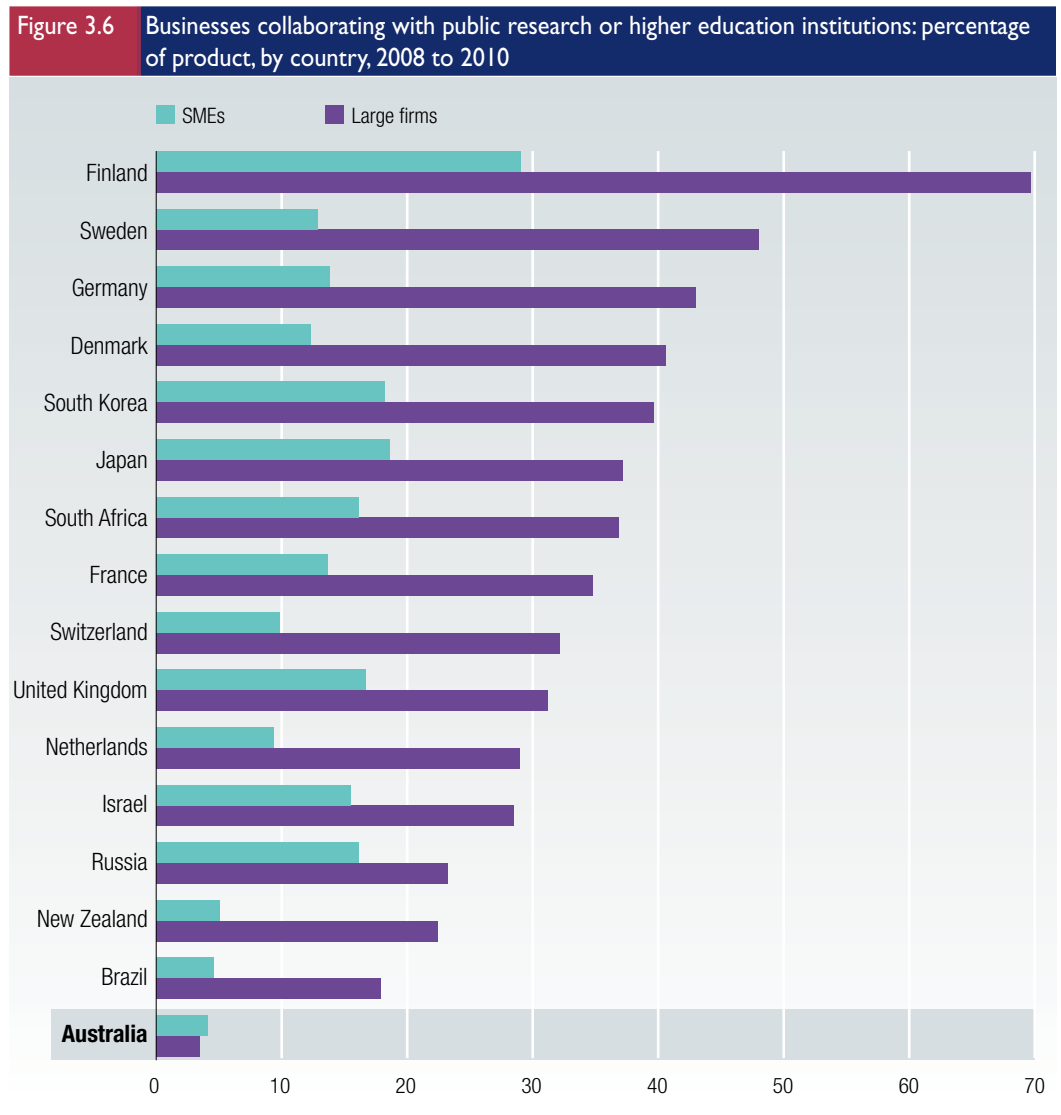


Source: OECD (2014)

3.7 Business collaboration with research institutions

The level of collaboration between business and research institutions is viewed as an important indicator of the flow and strength of knowledge exchange in a research system. This is consistently highlighted as an area of weakness for Australia.

Australian firms are among the poorest collaborators with public research or higher education institutions in the OECD (see Figure 3.6). The basic causes of this have been the subject of many publications and policy processes for several decades, but there has not been a substantial improvement in Australia's position.



Source: OECD (2014).

3.8 The Global Innovation Index

In 2014 Australia achieved its highest ranking in the Global Innovation Index—17th, up two positions from 2013. The Global Innovation Index 2014 covers 143 economies and uses 81 indicators across a range of themes. Overall, Australia is recognised as an innovation leader with a competitive and open economy.

Australia has continued to score well in innovation inputs (including R&D, infrastructure and human capital), the levels of tertiary education being highlighted as an area of strength. Australia's weakness lies in the innovation outputs, especially knowledge diffusion. The disparity between our inputs and outputs is the reason for our low ranking on the Innovation Efficiency Ratio, which provides an indication of how much innovation output a given country is getting for its inputs.

Although there has been an improvement in our efficiency ratio position globally—a ranking of 81 in 2014, up from 116 in 2013—this remains an area of weakness for Australia, as demonstrated in Table 3.2.

Table 3.2 Global Innovation Index ranking, by country, 2014

Overall rank	Country	Innovation Efficiency Ratio rank	Innovation Input rank	Innovation Output rank
1	Switzerland	6	7	1
2	United Kingdom	29	3	4
3	Sweden	22	6	3
4	Finland	41	5	6
5	Netherlands	12	11	2
6	United States	57	4	7
7	Singapore	110	1	25
8	Denmark	61	9	12
9	Luxembourg	9	21	5
10	Hong Kong	99	2	24
11	Ireland	47	12	11
12	Canada	86	8	20
13	Germany	19	19	8
14	Norway	51	14	14
15	Israel	42	17	13
16	South Korea	54	16	15
17	Australia	81	10	22

Source: Cornell University et al. (2014)

3.9 Patents

Patents are used as an indicator of a country's ability to translate knowledge generated by R&D into commercial applications. A triadic patent—a series of corresponding patents simultaneously filed at the European Patent Office, the United States Patent and Trademark Office and the Japan Patent Office—indicates that the applicant thinks the invention is of high economic value given the costly application process for patents in those markets.

Table 3.3 shows that the number of Australian triadic patents obtained in 2012 was low in comparison with most other countries. The number has been in decline since 2008. In 2012 Australia's share of triadic patents among all OECD nations was 0.46 per cent (OECD 2014). It should be noted, though, that methods of protecting intellectual property beyond patents are being used more widely both in Australia and internationally.

Table 3.3 Number of triadic patents obtained, by country, 2012

Country	No. of triadic patents
Japan	13,168
United States	12,722
Germany	4,749
South Korea	1,913
France	1,827
United Kingdom	1,340
China	998
Netherlands	817
Switzerland	705
Sweden	650
Canada	512
Finland	305
Israel	277
Denmark	234
Australia	197
Singapore	83
Russia	48
New Zealand	37
South Africa	26

Source: OECD (2014)

4

The comparator countries

As shown in Chapter 3, Australia's research performance, as measured by a range of indicators, shows areas of strength and areas of weakness. In terms of academic impact, Australia compares favourably but could improve relative to the highest performing nations. The areas of weakness primarily relate to knowledge exchange—especially the very low levels of business collaboration with research institutions.

This chapter compares Australia's performance with that of eight other nations. Switzerland, Denmark and the Netherlands were chosen because they are world leaders in research and have economies of similar size to Australia's; Singapore, South Korea and Malaysia were chosen because of the rapidity of their improvement in research performance in the past two decades; the United Kingdom and Canada are compared because of their structural and cultural similarities to Australia. There are, of course, a range of other countries that could have been included—for example, the United States and China—but the differences in the scale and structure of their systems make comparison more difficult.

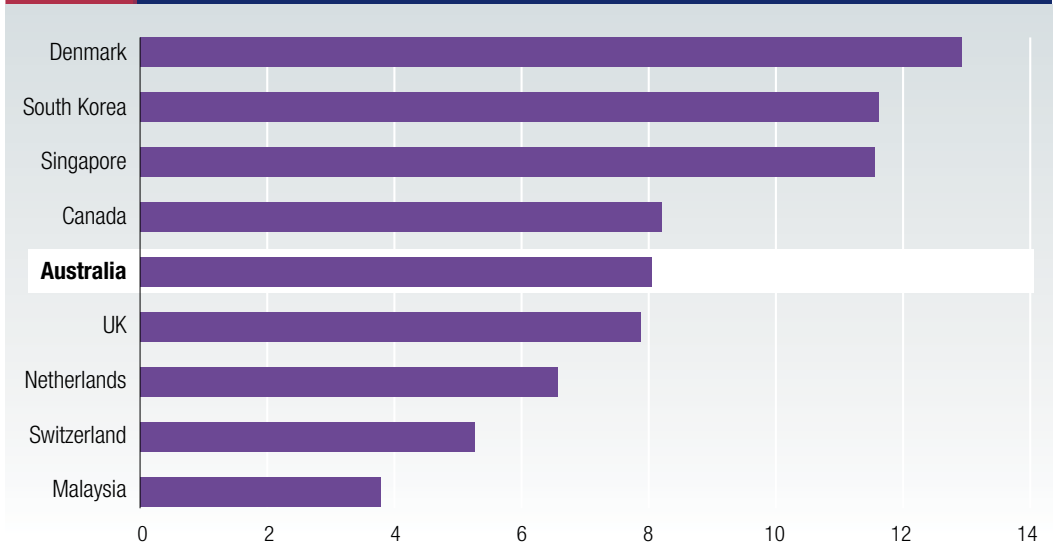
To place Australia's research performance in context, we examine the policy settings of these comparator nations. We look at how the nations' governments facilitate collaboration between industry and universities, where policy responsibility for research and innovation sits, and whether there are investment targets for R&D expenditure. Other important contextual factors, such as the distribution of the research workforce, industry structure and geography are also explored.

4.1 Key indicators

4.1.1 Workforce

The size and distribution of a research workforce are important when considering relative research performance. Figure 4.1 shows the number of researchers per 1000 people in the labour force for Australia and the comparator countries. Interestingly, the numbers for Singapore and South Korea—the so-called Asian tigers—are higher than those for some of the world's research leaders, such as the Netherlands and Switzerland.

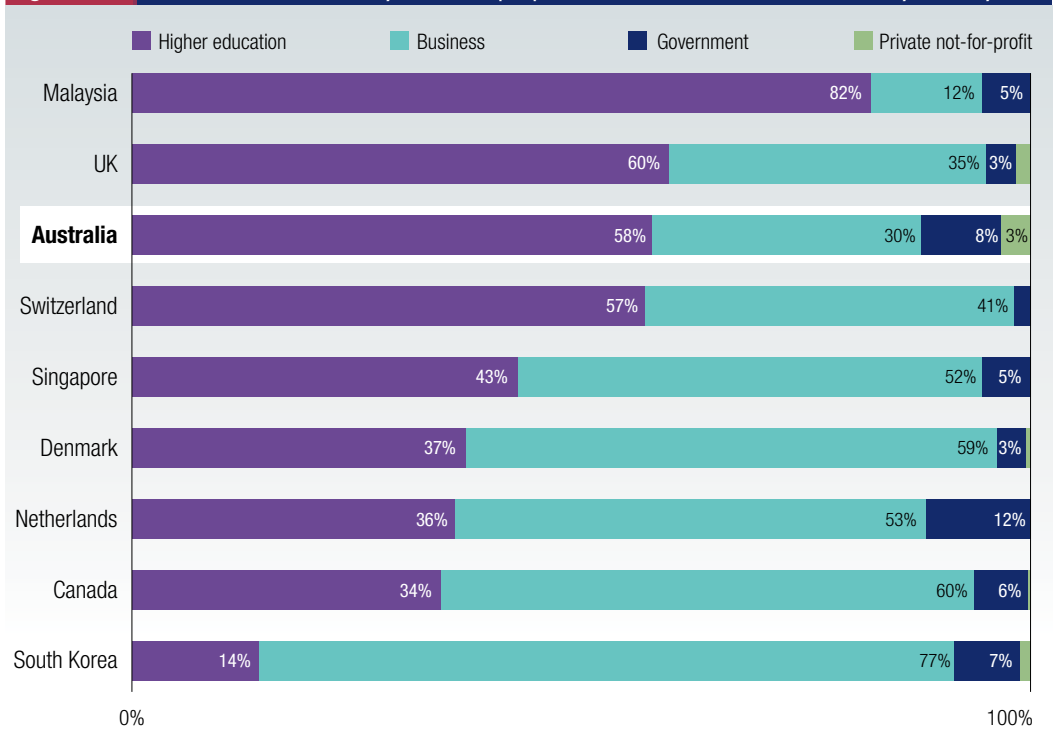
Figure 4.1 Number of researchers per 1000 labour force, full-time equivalent, by country, 2011



Note: Data for Australia and Switzerland are from 2008.
Source: UNESCO (2014).

As Figure 4.2 shows, there is some difference between Australia and the comparator countries in research workforce distribution by sector. Historically, both Australia and the United Kingdom have had most of their researchers concentrated in the higher education sector.

Figure 4.2 Number of researchers by sector as proportion of total research workforce, by country, 2011

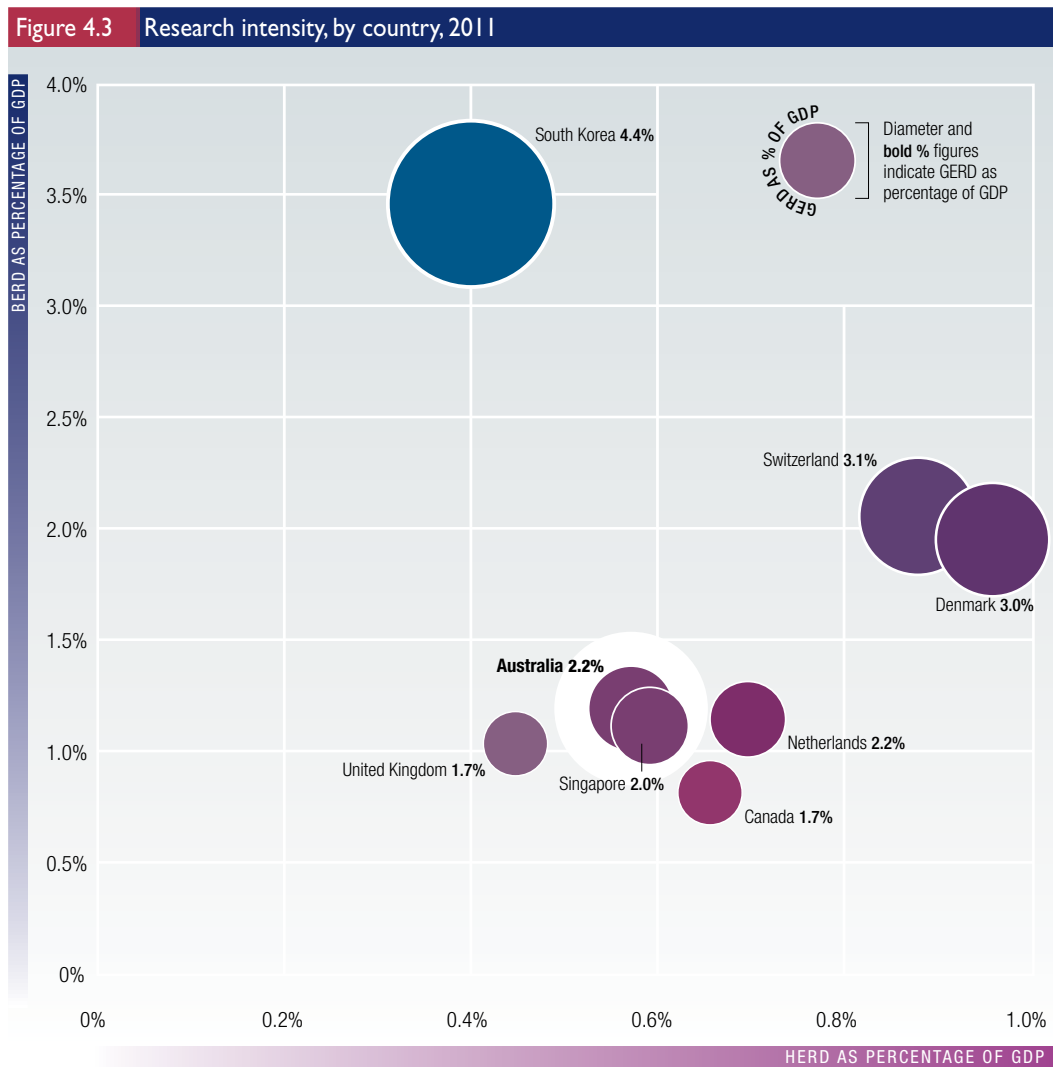


Note: Data for Australia and Switzerland are from 2008.
Source: UNESCO (2014)

4.1.2 Investment

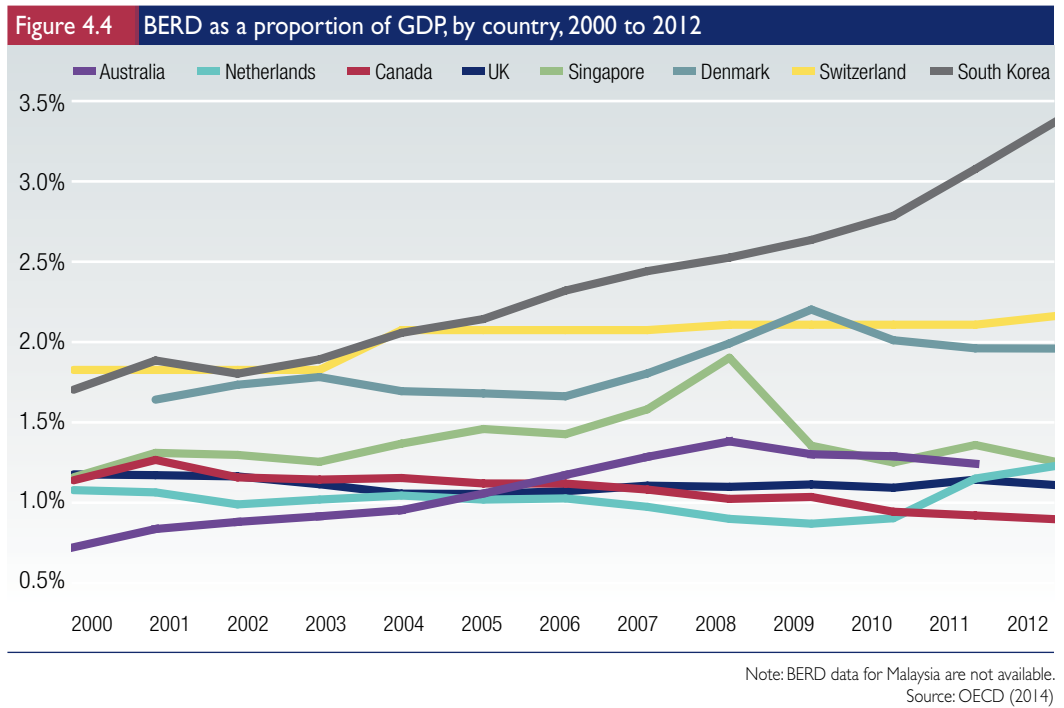
Australia's overall investment in research and development has been moderate when compared with that of other nations. In 2011 the OECD average for GERD as a proportion of GDP was 2.37 per cent. Australia's investment stood at about 2.2 per cent—below that of South Korea, Denmark and Switzerland and higher than the United Kingdom and Canada (OECD 2014). Although Malaysia has historically had much lower levels of GERD than the other comparator countries, it has steadily increased this investment in the past decade, from 0.47 per cent of GDP in 2000 to 1.07 per cent in 2011 (OECD 2014).

Figure 4.3 shows Australia's research intensity compared with that of some of the comparator countries. As is evident, Australia's proportions of HERD and BERD are similar to those of a number of the comparator countries. South Korea stands out as having the highest BERD as a percentage of GDP, a reflection of the strength of that nation's high-technology sector and its relationship with research institutions.



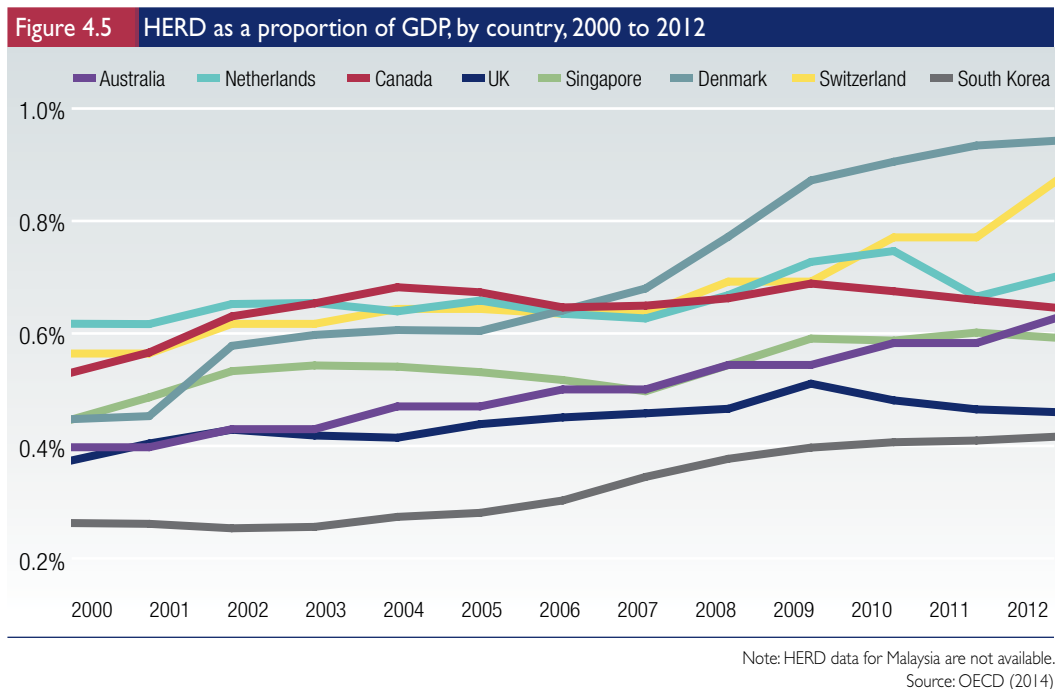
Note: HERD and BERD data for Malaysia are not available.
Source: OECD (2014).

As Figure 4.4 shows, Australian BERD in 2011 was moderate, at about 1.3 per cent of GDP, and constituted 58 per cent of GERD, but our rate of BERD is still well behind that of several leading nations.



In South Korea BERD reached 3.1 per cent of GDP in 2011, accounting for 77 per cent of GERD. Canada has experienced a steady decline in BERD since 2000, and this has been acknowledged as a concern for the nation’s research and development performance.

Figure 4.5 shows that Australia’s HERD investment over time has generally been lower than that of the Netherlands, Canada, Switzerland, Denmark and Singapore. As a proportion of GDP, however, Australian HERD increased from 0.58 per cent in 2010 to 0.63 per cent in 2012 (ABS 2014b).

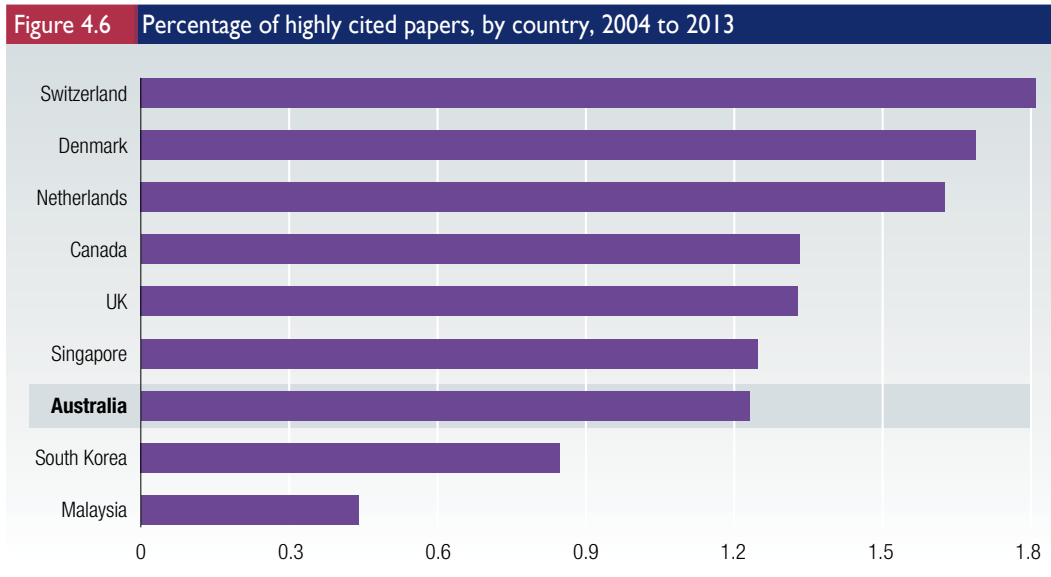


It is interesting to note that BERD investment declined in most countries as a result of the Global Financial Crisis in 2007 to 2008, while rates of HERD in most countries remained constant or increased during that time.

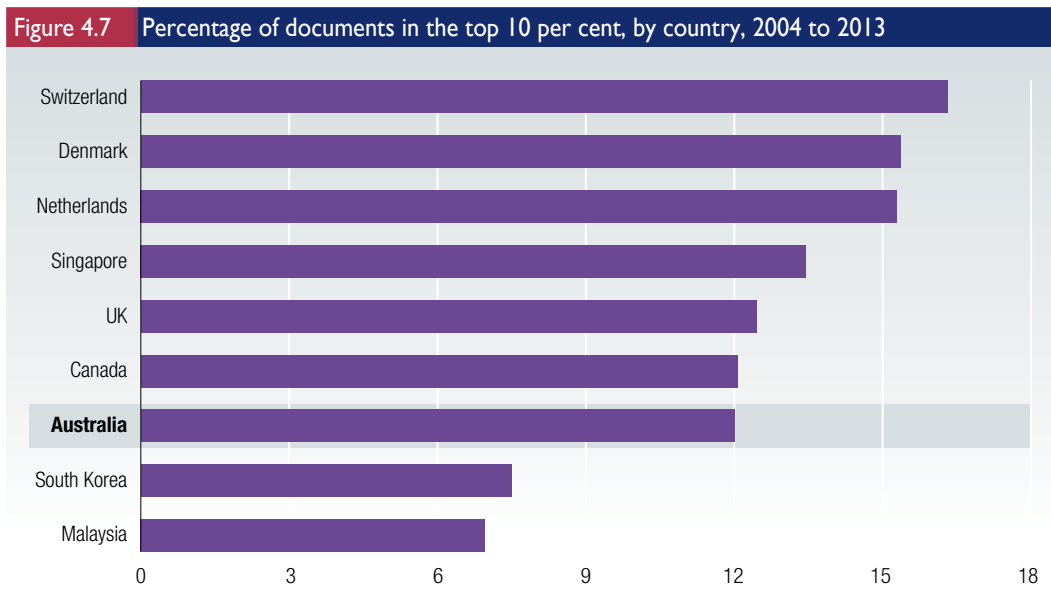
4.1.3 Academic impact

Given its small population—0.3 per cent of the world population—Australia performs reasonably well on a number of indicators of academic impact: we produce about 3.4 per cent of the world’s scientific publications, and in 2014 we ranked 10th for number of papers and total citations in Web of Science–indexed publications from 2004 to 2013 (Thomson Reuters 2014).

When considered alongside the comparator countries, however, Australia’s performance could be improved. Figures 4.6 and 4.7 show that from 2004 to 2013 Australia’s performance on the basis of two specific research indicators (proportion of documents in the top 10 per cent most cited documents and proportion of highly cited papers) was lower than that of most of the comparator countries, including world leaders such as Switzerland, Denmark and the Netherlands. We were also outperformed by Singapore.



Source: Thomson Reuters (2014)



Source: Thomson Reuters (2014)

4.2 Policy settings

The following section provides an overview of the policy settings of the comparator nations, with the aim of drawing out features or initiatives that could be useful for Australia to consider.

4.2.1 Switzerland

With about 8 million people spread across a land area roughly two-thirds the size of Tasmania, Switzerland's GDP (PPP⁶) in 2013 was about US\$434 billion (World Bank 2014), making it one of the wealthiest economies in the world. It is ranked as the world's number one country for innovation (Cornell University et al. 2014) and is consistently among the world's top research performers on the basis of a range of indicators.

Switzerland has a binary higher education system, with a clear division between research-based and professionally oriented institutions. Academic studies can be undertaken at the 10 cantonal (district) universities, the two federal institutes of technology, and the nine universities of applied sciences. There is considerable diversity among the cantonal universities and federal institutes as a result of their differing histories, approaches and research focus.

The industrial sector is a vital component of Switzerland's economy. The main industrial 'clusters' are chemicals, pharmaceuticals and biotechnology; medical technology; financial services; and the machinery, electrical engineering and metals industry. The sector is dominated by SMEs, with almost 99 per cent of firms having fewer than 250 employees (Switzerland Global Enterprise 2012). Private companies—particularly in the pharmaceutical, chemical and engineering industries—finance a significant amount of the country's research and development.

The Swiss research system is guided, funded and monitored by both federal and cantonal governments. The federal government provides funding to cantonal universities and the universities of applied sciences through legislation. The funds can be used to benefit research and university structures (that is, by purchasing research infrastructure) or to support research projects that encourage cooperation between the two levels of government.

Federal support for university research is also provided through a number of competitive grant schemes that are medium to long-term in nature and give priority to research of national significance. Additionally, there are a number of 'career schemes' that promote scientific talent through grants and exchange programs; an example is the Early Postdoc Mobility Fellowship. Knowledge transfer and technology are considered integral parts of research, and 10 per cent of project funds in nominated competitive schemes are earmarked for this purpose.

Cantons have full sovereignty over their universities and provide the majority of the universities' operational funds. Universities have full discretion in how these funds are allocated according to research and teaching priorities.

Although Switzerland's research and innovation policy has been consistent, stable and well coordinated since the early 2000s, in 2013 it was decided to bring responsibility for research, innovation and higher education into a single portfolio—the Federal Department of Economic Affairs. The intention was to minimise fragmentation between the federal and cantonal governments and to strengthen the link between the country's economic goals and its research and innovation agenda.

The primary purpose of the country's research, science and innovation policy, the ERI Message, is to increase R&D and innovation capabilities. The policy has three explicit goals—to ensure that the education system provides skills that match market demand; to strengthen competitive funding and increase R&D and innovation capabilities; and to build research and economic activities on the principles of equal opportunity, sustainability and competitiveness. Notably,

6 Purchasing power parity, or PPP, is used to determine the relative value of different currencies.

in this policy the government committed to funding the system at an annual growth rate of 3.7 per cent, a much higher rate than that applying to other policy areas.

The federal agency for innovation uses a range of mechanisms to facilitate collaboration between universities and industry. One of these is a 'voucher' scheme, which is essentially a commitment by the innovation agency to provide federal funding for an approved R&D project. Partnerships between public and private institutions tend to develop naturally in Switzerland because there is national consensus on the importance of collaboration to the country's research performance and, in turn, its economic prosperity.

Direct funding mechanisms for business investment in research and development are largely absent; rather, the focus is on fostering positive framework conditions for investment. This approach has been relatively successful: almost 75 per cent of GERD was provided by the business sector in 2011 (OECD 2014). The government has, however, had little effect on the R&D investment behaviour of multinational firms: among European Union nations, Switzerland has one of the lowest rates of foreign business investment.

4.2.2 Denmark

A nation of 5.6 million people and with a land area about two-thirds the size of Tasmania, Denmark had a GDP (PPP) of approximately US\$240 billion in 2013 (World Bank 2014). It has enjoyed a strong international position in terms of research, science and innovation indicators during the past 15 years and is commonly characterised as having one of the most efficient, well-performing research systems in the world. In 2014 it ranked eighth in the world for innovation (Cornell University et al. 2014).

Denmark has a binary higher education system. There are eight universities, 10 university colleges, 10 academies of higher education, four schools of maritime education and training, and 14 university-level institutions of fine and performing arts, design and architecture.

The Danish economy is characterised by a mix of low-technology and knowledge-intensive industries, and its business sector is dominated by small to medium enterprises, with many businesses having fewer than five employees (Statistics Denmark 2014). Since 2010 the federal government has increased its emphasis on engaging SMEs in collaborative research through providing extra funding to SME-targeted schemes.

Policy responsibility for research, development and innovation rests with the federal government, which allocates funding to universities through a two-pronged approach—fixed core funding (block grants) and competitive grants programs.

Denmark differs from Australia, and most other nations, in that core funding is allocated on the basis of input-oriented measures that are primarily concerned with the sufficiency of resources for research, rather than output-oriented measures based on efficiency and defined research results (Auranen & Nieminen 2010). Public funding of universities has increased consistently since 2009.

Competitive grant funds are administered by a range of agencies and target basic, applied and strategic research.

Denmark does not have a single national science and research policy; instead, it has a suite of documents that outline the nation's research and development objectives. Among the goals common to all the policies are increasing collaboration across government departments, maintaining a strong focus on internationalisation, supporting research mobility, and pursuing areas of strategic research significance.

The Danish Government has also set a number of explicit goals for research and innovation. The aspiration is that by 2020 the nation will be among the top five European OECD countries with the highest share of innovative enterprises, the highest private investment in research and development as a share of GDP, and the highest share of highly educated employees in the private sector.

The government encourages knowledge exchange between universities and industry through graduate and postgraduate placements in industry. Its longstanding Industrial PhD Programme, established in 1970, is internationally recognised for its successful integration of academic research in a business environment. The Industrial PhD student is employed by a private company and concurrently enrolled at a university, dividing their time between their employer and the university during the three years of the project. The company receives a monthly wage subsidy from the Danish Agency for Science, Technology and Innovation, and the university receives funds to cover its supervision expenses.

Denmark's focus on increasing its international links has seen the nation enter agreements with the United States, Brazil, China, India, Japan and Israel and establish partnership agreements with Stanford University and the Japanese Science and Technology Agency. It has also established centres of innovation in Silicon Valley, Shanghai, Munich, Hong Kong and Sao Paulo.

4.2.3 The Netherlands

A densely populated country of 17 million people in a land area roughly half the size of Tasmania, the Netherlands had a GDP (PPP) of around US\$729 billion in 2013 (World Bank 2014). Despite only moderate investment in research and development, the nation consistently performs well in global research rankings. In 2014 it was ranked fifth in the world for innovation (Cornell University et al. 2014), and it has high publication outputs and high impact scores.

The Netherlands has a binary system of higher education, with 13 research universities and over 40 universities of applied science, most of which are teaching-focused and practically oriented. Additionally, there are five small privately funded universities that do not receive government funding but are accredited to provide teaching programs in a limited range of fields. The universities of applied science conduct applied research, but they do not receive substantial public research funding and research is not a core activity of their academic staff. There are also numerous public research institutes.

There is a clear distinction between the 13 research universities and other higher education institutions, but there is no clear distinction between the research universities in terms of research performance. Consistent with its egalitarian tradition, the Netherlands has a relatively uniform structure of research universities in terms of status, institutional differentiation being mostly based on discipline specialisation or comprehensiveness.

Universities obtain block grant funding from the Dutch Government and, as in Australia, these grants are determined by a combination of teaching indicators, research indicators and historical factors. Competitive grants are provided through agencies such as the Netherlands Organisation for Scientific Research, the Research Council for Technical Science, and the Royal Netherlands Academy of Arts and Science.

In its 2011 industrial policy 'To the top' the Dutch Government identified nine top-performing sectors intended to drive the nation to become one of the world's top five knowledge economies by 2020. These sectors are agro-food, horticulture and propagating stock, high-technology materials and systems, energy, logistics, creative industry, life sciences, chemicals, and water. The majority of Dutch businesses are small to medium enterprises.

Policy responsibility for research and innovation rests with two federal ministries. Since the introduction of the 'To the top' policy, however, there has been a concerted effort to develop an overarching framework for higher education and industry policy. When the 'To the top' policy was introduced some block grant funding was redirected towards research agendas and programs oriented to the nine top-performing sectors, and competitive grants schemes were tailored to reflect the government's new priorities. In October 2013 business enterprises, knowledge institutions and the government signed 'innovation contracts', whereby stakeholders promised an annual research investment of almost €2 billion for the top sectors to build on existing scientific excellence and generate innovative solutions to societal problems.

The nation's overall investment in research and development has remained strong despite an economic contraction in 2009 and a recession in 2011. Further, the government has committed to

increasing its investment: it has a goal of investing 2.5 per cent of the nation's GDP in R&D by 2020. Levels of business investment in research are relatively low: BERD accounted for 1.07 per cent of GDP in 2011. This is partly attributable to the structure of the business sector, which is dominated by a large service sector and a small manufacturing industry that is focused on medium technology sectors.

The government introduced temporary measures to increase business investment in research and development in the late 2000s. A specialised tax credit scheme was also introduced to encourage public–private partnerships in research related to the top-performing sectors. These measures resulted in a noticeable increase in BERD, from 0.85 per cent of GDP in 2009 to 1.07 per cent in 2011.

In comparison with Switzerland and Denmark, the Netherlands invests modestly in research and development, yet it performs exceptionally well. This is partly a result of the high degree of collaboration. Fifty-eight per cent of Dutch top-cited articles between 2003 and 2011 were co-published with international research institutes (OECD 2013a), and in the Leiden rankings the Netherlands has the top two universities for the proportion of collaborative publications with industry (Leiden University 2014).

4.2.4 Singapore

A city–state of 5.3 million people inhabiting a land area smaller than the ACT, Singapore had a GDP (PPP) of around US\$425 billion in 2013 (World Bank 2014). In spite of its small size, the nation performs very well in terms of a number of research and innovation indicators: in 2014 it was ranked seventh in the world for innovation (Cornell University et al. 2014).

Singapore's higher education system is binary in nature. It has six public universities, five polytechnics, 10 institutes of technical education, two publicly funded private arts schools, and a number of private universities.

One of the world's most industrially advanced nations, Singapore has a diverse range of industry sectors (among them manufacturing, oil refining and the travel industry) that are dominated by small to medium enterprises. SMEs in high-technology sectors, however, have a much smaller role in the overall economy in Singapore than is the case in other developed markets, such as South Korea. Manufacturing is responsible for a significant amount of the nation's output, electronics manufacturing being the cornerstone of the economy. Digital technologies and biomedical and pharmaceutical manufacturing are evolving as new areas of focus.

The Ministry of Trade and Industry has policy responsibility for the nation's research agenda and provides funding to a range of agencies. The Ministry of Education provides core funding to universities for research, focusing on basic research with longer time frames and a goal of knowledge creation. Competitive grants funds are administered by the National Research Foundation, which emphasises longer term strategic research programs.

The government's primary research organisation, A*Star, is central to the nation's research, development and innovation agenda. A*Star's mission is to transform Singapore into a world-class scientific research hub by supporting the development of intellectual, human and industrial capital. It runs a number of programs that support the translation of research into commercial products; it also nurtures domestic PhD students to serve in both the public sector and industry through scholarships and awards.

Singapore's government-funded Campus for Research Excellence and Technological Enterprise, CREATE, is an excellent example of the opportunities provided by co-location of researchers. Situated at the National University of Singapore, CREATE has helped the nation establish formidable research partnerships with a number of world-leading universities, including the Massachusetts Institute of Technology, the University of California, and the Swiss Federal Institute of Technology.

The government-established Biopolis and Fusionopolis are international purpose-built research hubs that facilitate R&D collaboration between public research institutes and industry. Biopolis focuses on biomedical sciences, while Fusionopolis concentrates on physical sciences and engineering. The government views these hubs as instrumental in furthering Singapore's research success.

As part of its economic growth plan, the Singaporean Government has drawn a clear distinction between research-intensive universities and higher education providers. The research-intensive universities—the National University of Singapore and Nanyang Technical University—account for more than 75 per cent of the country’s research outputs, and their distinction from other universities has been explicitly supported by the government, with all five government-supported Research Centres of Excellence located in these two universities. The research-intensive universities are, however, increasingly partnering with the country’s private universities and polytechnics in pursuit of research excellence and economic growth.

Since the introduction of the government’s Research and Development Assistance Scheme in 1981 there has been strong research collaboration between Singaporean universities and industry. Programs designed to support this collaboration span the entire business cycle, from research to tax incentives to venture developments. In the past five years the government has also increased its support to SMEs to encourage their involvement in research and development.

4.2.5 South Korea

South Korea has 50 million people inhabiting a land area less than half the size of Victoria. In the past two decades the nation’s rate of economic growth has been extraordinary, and it is now a regional power, with a GDP (PPP) in 2013 of around US\$1.7 trillion (World Bank 2014). Of all the nations examined in this paper, South Korea expends the greatest amount on research and development: in 2013 it invested 4.4 per cent of its GDP. In 2014 South Korea was ranked 16th in the world for innovation (Cornell University et al. 2014).

South Korea has a large and highly diversified higher education system. There are approximately 350 higher education providers—universities, colleges, junior colleges, graduate schools, cyber universities, industrial universities, and universities of education. Eighty-five per cent of higher education institutions are privately run, with about 175 private and 40 public universities.

South Korea’s economy is dominated by high-technology industries, principal among them electronics, telecommunications, auto production, steel, shipbuilding and chemical production. *Chaebols* (Korean conglomerates, such as Hyundai and Samsung) have a powerful presence in a number of sectors, but the majority of industry consists of small to medium enterprises.

Policy responsibility for research and innovation sits across two ministries. There is national consensus that research, science and technology are central to South Korea’s transition to a knowledge economy. The strength of this consensus is reflected in the government’s goal to invest 5 per cent of the nation’s GDP in research and development by 2017.

In contrast with Australia, South Korea’s research sector is dominated by public sector research organisations and universities play a smaller role. On average, public sector organisations receive 50 per cent block funding through the finance ministry and various research councils (Ko 2012). They also receive funds from other ministries through competitive grants schemes, and many of their projects are related to joint research among industry, academia and research institutes.

South Korea has encouraged a ‘free to fail’ culture in research, in which high-risk basic research is supported and researchers receive sufficient medium and long-term funding to allow them to focus on their research as opposed to constantly submitting research proposals. Competitive grants schemes fund projects that support early to mid-career researchers, group-research laboratories and long-term projects in identified areas of focus—for example, nanomaterial technology and biomedical technology.

The South Korean Government has recognised the importance of keeping a balance between basic, applied and experimental research in continuing the country’s economic success. In 2012 it committed to increasing its basic research capabilities and outputs through establishing the Institute for Basic Science, a network of 50 research centres, each with an annual budget of about A\$10 million. The institute encourages ‘creativity and adventure’ in long-term research and argues that research performance should not be measured by publications (Park 2012).

Government policy in the late 2000s focused on strengthening the research of universities, but the aim of current policy is to foster partnerships between universities, public research organisations and industry. The government provides a range of programs for both universities and SMEs to promote collaboration and technology transfer. The programs provide funds to develop technology-licensing institutes within universities and establish technology holding companies to facilitate the commercialisation of university research results.

4.2.6 Malaysia

Malaysia, with 29 million people, has a land area less than half the size of New South Wales. In 2013 its GDP (PPP) was about US\$692 billion (World Bank 2014). Although it is a middle-income country, Malaysia's economic growth trajectory has been impressive. In recent years the government has recognised the importance of research and development in helping the nation become a competitor in the global economy. In 2014 Malaysia ranked 33rd in the world for innovation (Cornell University et al. 2014).

The nation's higher education sector is relatively large and diverse. There are 20 public universities, more than 30 private universities and university colleges, four foreign university branch campuses, more than 20 polytechnics, almost 40 community colleges and about 500 private colleges. This diversity is seen as central to Malaysia achieving the goal of becoming a regional education hub.

Malaysia's economy is dominated by multinational enterprises (such as Hewlett-Packard and Motorola) that assemble and export electronics and other manufactured products. Its business sector is dominated by small to medium enterprises, although these firms engage in little research or innovation activity (OECD 2013a).

There is an increasing trend towards competitive grants schemes and performance-based funding for universities. The Malaysian Government is committed to 'outcomes-based budgeting', whereby funding is determined by a university's ability to satisfy a set of performance criteria. There are several competitive grants schemes targeting different kinds of research, and multidisciplinary, multi-institution research is encouraged.

Policy responsibility for research sits across two federal ministries, with several other ministries and agencies contributing to the overall science, research and innovation agenda. In 2006 the government designated four public universities as 'research universities' to support the country's transition to a knowledge economy. Although controlled by the government, these research universities have considerable financial and institutional autonomy in relation to research and receive additional funding to pursue research programs of benefit to the nation.

The 21st century has seen a major change in the Malaysian Government's approach to research and development. The nation's five-year economic plans have clearly expressed the importance of research and development in helping Malaysia achieve economic prosperity: 'science, research and education can ... serve as a powerful engine of innovation in an economy' (Economic Planning Unit 2010, p. 80). The government has committed to an overall investment of 1 per cent of GDP on R&D by 2015 and increasing the number of researchers, scientists and engineers to 100 per 10,000 labour force by 2020.

The links between universities and industry in Malaysia are weak, and the nation's success in patents and commercialisation has been limited. Strengthening these links is an important policy focus. In recent years the government has introduced incentives for university researchers and inventors by offering a cash reward on the disclosure of an invention and funding for initial development when a patent is granted.

Knowledge exchange between universities and industry is facilitated by the Industrial Attachment Programme, which is similar to Denmark's Industrial PhD Programme. It is designed to provide 'real-world' experience to research students training in technical disciplines and help them successfully move into employment once their studies are complete.

4.2.7 The United Kingdom

The United Kingdom has a land area a little larger than that of Victoria. It is home to 63 million people, and in 2013 its GDP was around US\$2.3 trillion (World Bank 2014). The nation is well-recognised as a top performer in research: in fact, it is the third largest contributor to the world's research output (behind the United States and China) and produces 14 per cent of the world's most highly cited papers (Cunningham & Sveinsdottir 2014). In 2014 it was ranked second in the world for innovation (Cornell University et al. 2014).

The higher education system in the United Kingdom is unitary and diverse, consisting of more than 150 universities, higher education colleges and specialist conservatories. As in Australia, the sector is overwhelmingly dominated by public universities, with only four private universities. The devolved administrations in Wales, Scotland and Northern Ireland have policy responsibility for their higher education sectors. UK universities have a high degree of autonomy in relation to research.

The services sector dominates the UK economy, the financial services sector contributing significantly to the country's output. The pharmaceutical sector also plays an important role: the United Kingdom has the third largest share of global pharmaceutical R&D (Department of Business, Innovation and Skills 2011). The majority of businesses are small to medium enterprises.

Like Australia, the United Kingdom has a dual support system for funding university research. Core research funding is provided through block grants through the Higher Education Funding Council for England, while seven research councils provide support for research through competitive grant schemes. Block grants are used to fund research infrastructure and strategic research priorities; competitive grants are used to fund specific projects and programs. Block grants are distributed selectively on the basis of an assessment of the quality of a university's research, as measured in the Research Excellence Framework, which from 2015–16 will include an 'impact' component.

In an attempt to provide a clear policy direction for the United Kingdom as a whole, and to redress problems associated with devolved administrations and separate research and innovation policies in Scotland, Wales and Northern Ireland, responsibility for research and innovation throughout the UK was placed with the Department for Business, Innovation and Skills in 2011.

Released in 2011, the government's research policy, the Innovation and Research Strategy for Growth, heralded a more comprehensive approach to improving the country's research performance. In the policy the government acknowledged that the United Kingdom has traditionally performed poorly in translating research into technologies or products, noting that it must strengthen its ability to accelerate the development of emerging technologies and to capture the value chains linked to these technologies. The policy openly supports 'blue sky, curiosity-driven' research in balance with applied research: it is contended that both result in economic and societal benefits.

To improve links between universities and industry, the government has focused its policy attention on the business sector. Innovate UK (formerly the Technology Strategy Board), the nation's innovation agency, has been made a central figure in science, research and innovation policy and administers a number of new programs aimed at supporting university–industry collaboration and long-term knowledge exchange between research partners.

The programs administered by Innovate UK span the spectrum of research engagement—from identifying potential research partners to subsidising the cost of salaries and funding infrastructure to enable co-location of researchers. Embedding knowledge in industry has been encouraged through the Knowledge Transfer Partnerships program, which is designed to encourage three-way partnerships between business, universities and graduates. Introductions to potential research partners have been facilitated by Innovate UK's Knowledge Transfer Networks. Each network is dedicated to a specific field of research, and communication with experts is enabled through an online platform.

The UK Government has also created ‘Catapult’ centres, which are centres of technology and innovation that connect businesses with the research and academic communities and are intended to close the gap between concept and commercialisation. There are eight Catapult centres, each one focusing on a particular area of research.

The Higher Education Funding Council for England also administers the Higher Education Innovation Fund, which supports a wide range of knowledge exchange and transfer activities in and between universities. When deciding the allocation of the most recent rounds of HEIF funds, HEFCE asked universities to demonstrate how their knowledge exchange practices are integrated into their institution’s mission, how they engage with small to medium enterprises, how they collaborate with other innovation organisations, and how they collaborate and communicate with the community.

4.2.8 Canada

With a land area 1.3 times that of Australia, Canada has a population of about 35 million, and in 2013 had a GDP of approximately US\$1.5 trillion (World Bank 2014). Although it is a consistent performer in research and development, its ability to translate knowledge into commercial applications has been highlighted as an area of concern (Expert Panel on Business Innovation 2009). In 2014 Canada was ranked 12th in the world for innovation (Cornell University et al. 2014).

Canada’s higher education system is large and diverse. There are more than 160 recognised public and private universities (including theological schools), more than 180 recognised public colleges and institutes, more than 60 university-level institutions, and about 50 college-level institutions.

Canada’s economy is dominated by the services sector, but the manufacturing, automobile engineering and aircraft engineering sectors are also strong. Small enterprises account for the majority of businesses: there are few medium and large ones.

The higher education system in Canada is highly decentralised; universities are relatively autonomous and regulated by their respective provincial governments. As a consequence, distinctive systems of higher education have evolved in each of the 10 provinces, with higher education policy being shaped by the geographic, economic, historical, cultural and social characteristics of each province.

There is no federal ministry for education, and this means there are no clear mechanisms for national higher education policy development. The Canadian Government does, however, have constitutional authority over areas that intersect with the higher education sector—for example, science and technology and research and development. The federal government primarily administers research funding to universities through three research councils and various programs.

The three research councils—the Canadian Institutes of Health Research, the Natural Sciences and Engineering Research Council, and the Social Sciences and Humanities Research Council—constitute the federal government’s ‘tri-council’. The tri-council administers a number of competitive grants schemes with purposes ranging from facilitating knowledge translation to fostering collaboration with industry and supporting the purchase of infrastructure. In early 2014 a new C\$1.5 billion competitive grants scheme was announced to support Canadian higher education institutions in improving their research performance.

Provincial funding for university research and development varies markedly between provinces, but the overall level of funding—about 5 per cent of total funding—is low in comparison with federal funding. In addition to funding research in universities, provincial governments provide financial support to R&D projects that are of economic importance to their region. They also co-fund, with the federal government, research projects that are of mutual benefit to both tiers of government.

Canada’s economic goals underpin the nation’s research and innovation policy. The main research policy has several aims—to develop, attract and retain a highly skilled workforce; to use research and development to generate innovation; and to transform knowledge into applications that will improve wealth, health and wellbeing. The policy was also designed to increase business investment in research and development but, given the steady decline in BERD in the past 10 years, there have been claims that the policy has not been successful. Since Canadian-owned multinationals are

the entities most likely to engage in product innovation and R&D spending, Canada's failure to cultivate these firms has influenced the country's weakness in research and development (Expert Panel on Business Innovation 2009).

The Canadian business sector's long-term reluctance to collaborate with publicly funded research organisations strikes a parallel with the Australian situation. Despite the messages delivered in both nations about the importance of innovation to the country's economic prosperity, there has been little change in the behaviour of the business sectors over time. The Canadian Council of Academies points out that examining innovation activities themselves will not provide an answer to why business does not invest; rather, it suggests looking at factors that influence business strategy, among them structural characteristics (firm size and sector mix), competitive intensity, the climate for new ventures (including the availability of venture capital), public policies (government incentives) and business ambition (Expert Panel on Business Innovation 2009).

5

Policy considerations

The Australian university sector may be on the brink of a period of great change. Although the focus of the higher education reform package the Australian Government announced in the 2014–15 Budget relates primarily to teaching and learning, the reforms will inevitably have a major effect on the level and breadth of research activity. Research and teaching are strongly linked in Australia’s universities, and these links are fundamental to the sector’s performance.

As outlined in the introduction, a number of important processes that consider substantial parts of the research system are imminent or under way. The Australian Government has outlined its aims for university research, among them ensuring Australia’s research effort is addressing key national priorities and supporting the translation of research into commercial outcomes, along with strengthening our international performance. In order to achieve these aims, a coherent set of policy instruments is needed as part of an overall strategy.

The international analysis in Chapter 4 provides information about the strategies being deployed in comparator countries to achieve their identified goals. Although the approaches taken vary, their unifying feature is a strong commitment to continued public support for university research and a recognition of the vital role such research plays in a nation’s prosperity.

This chapter narrows the focus to university research within the broader system. If universities are to flourish in these changing times and to meet the Australian community’s expectations, they must have a clear strategic direction. Pursuing differentiation and building a strong reputation are vital. In terms of research effort, this will include consideration of factors such as the following:

- areas of research excellence
- domestic and international collaboration
- industry partnerships
- engagement with government
- connections with the community—including ways to leverage local resources and characteristics to promote economic and social improvement.

To assist the debate on future directions for university research, this chapter outlines a range of policy considerations, building on our analysis of the current system and the initiatives in comparator countries.

5.1 Reward and recognition mechanisms at the researcher and university level

Universities perform many important roles in society, yet current domestic and international systems of comparison mainly use research performance to determine the relative standing of institutions. In Australia, the most visible assessment of university performance is the Excellence in Research for Australia initiative. Although the ERA directly affects only a small proportion of the funding provided, it is clear that universities have used the process to gain a better understanding of their research profile and to try to maximise the number of areas performing at or above world standard.

Concern has, however, been expressed that the focus on assessing research excellence in this way in isolation is distorting the reward and recognition systems, both at the researcher level and at the university level, and is devaluing other important areas of university responsibility such as teaching excellence and engagement with industry and the community.

As part of the higher education reforms announced in the 2014–15 Budget, the Australian Government is proposing a new website to allow students and parents to compare information about the education outcomes and student satisfaction for higher education providers—the Quality Indicators for Learning and Teaching. This could offer a new means of comparison for universities and could in turn lead to changes in the reward and recognition systems for staff.

There is also continuing discussion about how to assess the broader social and economic benefits from research more effectively. The UK experience is important here since it has progressed furthest down this path. The new Research Excellence Framework evaluation process currently under way uses case studies to assess the impact of research, which directly affects university funding.

Inclusion of some form of impact assessment has been debated in Australia at length since the original proposal to develop a quality assessment framework as part of the Backing Australia's Ability initiative was announced in 2004. The most recent discussion paper, released by the previous government in June 2013, raised the possibility of having a two-pronged approach, with case study assessment complemented by indicators that measure behaviours, activities and characteristics associated with subsequent benefit. The paper calls these indicators 'research engagement metrics' (DIICSRTE 2013).

The Australian Academy of Technological Sciences and Engineering has also called for a new approach to rewarding research and industry engagement, using income from commercialisation and industry as the primary metric. The combined income by four-digit field of research code would be compared on a full-time-equivalent basis with the national average to achieve a rating to complement the ERA (ATSE 2014). There are, however, questions about the uneven nature of the income and the robustness of the data at a field of research level that could create difficulties for such an approach. In addition, the use of one indicator in isolation could have unintended consequences, driving behaviours that are counter to the aim of fostering deep and productive collaboration.

A focus on engagement—rather than impact—might be a more practical approach to encouraging behaviour at the university and researcher levels that would increase the exchange of ideas, foster innovation, and improve the translation of research into broader benefits. Any new approach would, however, need to guard against creating perverse or unbalanced incentives and unduly increasing the administrative burden on the university sector. It is also important to maintain a focus on excellence.

Australia should continue to look carefully at the systems and approaches being implemented internationally and consider ways of improving reward and recognition systems to support diversity and ensure that universities are meeting the expectations of both the community and government.

5.2 Direction-setting mechanisms

A variety of processes and initiatives have been adopted, at the national level and more specifically, to set priority areas for research. At the national level, the National Research Priorities were announced in 2002 and were in force until new Strategic Research Priorities were announced in 2013 to replace them. One of the reasons given for this change was a perception that the National Research Priorities were not an effective mechanism for directing the Australian Government's research investment (DIISRTE 2012). The current status of the Strategic Research Priorities is unclear, but it is reasonable to assume that the government will want to continue to set national priorities.

As the rationale for changing to Strategic Research Priorities makes clear, one of the difficulties with prioritisation lies in ensuring that implementation leads to increased effort in vital areas and improved translation into real-world benefits. Historically, the link between national priorities and the existing funding and direction-setting mechanisms in Australia has been relatively weak. It has generally taken the provision of an issue-specific stream of funding to create a strong connection between the priorities set and the research funded. This approach can, however, lead to small initiatives that do not leverage the existing capacity or take into account broader system factors that can affect the outcomes—for example, workforce availability and pathways to take-up by end-users.

We have an opportunity to learn from recent international experience in priority setting. The National Science Challenges process in New Zealand (Ministry of Business, Industry and Employment 2014) and action plans for priority areas developed by Innovate UK (2014b) are of particular interest. Both of these processes are using a flexible and strategic approach, informed by experts, to determine specific investments beneath broad priority areas, with tailored funding mechanisms. This more hands-on approach to priority setting could be an option for Australia, with specific funding being provided as part of a wider framework that continues to support a broad range of research effort.

If more specific priorities were developed and gaps and issues were identified through a consultative process, universities would be assisted in their strategic planning. Increased clarity and transparency would support alignment with the Australian Government's goals and enable universities to make the most of their strengths, improving the effectiveness of the priorities.

There is also an increasing trend internationally to ensure that research priorities reflect a nation's broader economic goals. After the release of its industrial policy the Dutch Government realigned its research priorities to nine priority economic areas and redirected research funds towards projects that targeted these priorities. Singapore has long used its economic policy as a direction-setting mechanism for its research policy, this link becoming more explicit in the past 10 years as the nation sets more ambitious economic goals.

With all direction-setting mechanisms it is important to recognise the need for a balance between top-down strategic allocation and bottom-up researcher and university-led approaches. When looking at our comparator countries, it becomes clear that the strategies they have adopted support a balance of mission-led and investigator-led research and that the foundational role of basic research in building a competitive research system is understood.

5.3 Research funding mechanisms

Although there are a number of issues highlighted in this section, it is important to be mindful that the current system has served us well. As discussed in Chapter 2, Australian university research compares well internationally: this position would not have been achieved without the support provided by the Australian Government.

As outlined in Chapter 2 Australia has a dual-support mechanism for research funding for universities, with competitive project grant funding for direct costs and block grant funding for indirect costs. In contrast with some other dual-support systems, in Australia there is no automatic mechanism for ensuring increased indirect support when the level of direct support rises.

In a variety of policy documents and forums inadequate support for indirect costs has consistently been recognised as a serious concern for the Australian system. The balance of different funding types must be carefully considered as part of any policy discussions relating to changes to the current system of support.

The long time frames inherent in realising the benefits of research must also be recognised. Continuing, reliable support for the central components of the research system is vital. Stop-start funding arrangements for fundamental parts of the system compromise the efficiency and effectiveness of the nation's investment.

Deregulation of domestic student fees will probably have an impact on the level of general university funds available to support research, although the precise effects are not clear at this stage. It has also been suggested that the option of decoupling research funding from teaching and learning funding under the Commonwealth Grant Scheme could be considered as a further reform to the sector. This would constitute a major change to the structure of university research funding in Australia, and the ramifications warrant careful consideration.

5.3.1 Competitive funding

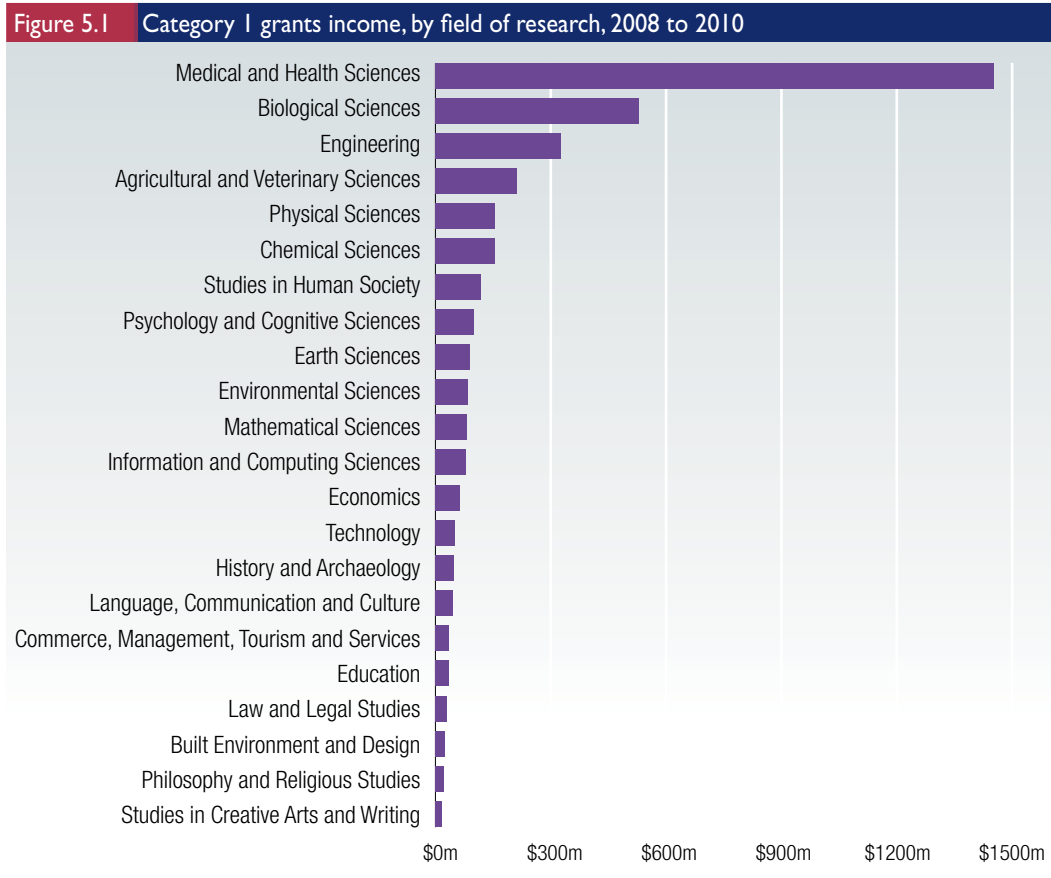
The use of competitive processes underpinned by peer review is an important feature of the top-ranking research systems. Such an approach provides a high degree of researcher autonomy and fosters a broad base of research capability.

There has been considerable discussion of ways the Australian Research Council and National Health and Medical Research Council can reduce the time taken for grant applications and extend the duration of grants, without affecting quality or substantially reducing success rates. The burden of the application and peer review processes combined with low success rates is reducing the time available for the research itself and has been consistently raised as an area of concern for the research system.

Both the ARC and the NHMRC are considering these issues. Researchers have been able to apply for up to five years of funding under the NHMRC's Project grants for some time, but only a relatively small proportion of applicants have taken up the option. For the 2014 funding round the terminology has been changed to 'five years or less', as recommended by the McKeon review (McKeon et al. 2010). There has been an increase in the number of five-year applications compared with 2013, but the majority of applicants are still seeking three-year grants, despite the NHMRC reporting higher success rates for five-year applications (ASMR 2014). The ARC has also included the ability to apply for up to five years of funding in its most recent rules for Discovery projects but expects to offer only a small number this year as the change is phased in.

The NHMRC is also seeking to streamline its application and assessment processes, building on much of the feedback offered at its Evolutions in Peer Review Symposium, held in February 2013. The aim of the project is to progressively introduce streamlined application and assessment systems, supported by improved guidance for applicants and training for peer reviewers.

The level of competitive funding available to support different areas of research was highlighted in the 2014–15 Budget by the decision to establish a Medical Research Future Fund. Medical and health-related fields of research already account for more than 55 per cent of competitive grants income received by universities (see Figure 5.1).



Source: Australian Research Council (2012)

A further unbalancing of the system could have serious adverse consequences for other disciplines that are essential to Australia’s prosperity and economic growth. Furthermore, Australia’s excellent reputation for medical research is dependent on the strong foundation provided by the underpinning disciplines; for example, materials science and nano-fabrication techniques are fundamental to the new bio-functional structures being created. The design work for the Medical Research Future Fund will also need to take account of how the indirect costs will be funded. It would be a poor policy outcome if the new fund were to compromise the overall health of Australia’s research system.

5.3.2 Block funding

At present three schemes provide block funding to universities to support the indirect costs of research: the Research Infrastructure Block Grants Scheme; the Sustainable Research Excellence Scheme; and the Joint Research Engagement Scheme. The most recent set of changes to the structure of the block grants was introduced as part of the previous government’s innovation statement Powering Ideas.

The SRE Scheme was created to ensure that higher education providers are better placed to meet the indirect cost of research activities that is not met by the various competitive grant programs. The funding formula for the SRE Scheme is very similar to that used for the RIBG Scheme: Category 1 income (competitive grants) is the major input, but Excellence in Research for Australia results and the indirect costs of research are used as moderators to make relatively modest adjustments. The other main change was to rebadge funding previously provided through

the Institutional Grants Scheme as the new JRE Scheme. The funding formula was altered to remove Category 1 income from the JRE calculation, with the aim of giving greater emphasis to end-user research by encouraging and supporting collaborative research activities between universities, industry and end-users.

Anecdotally, it appears that the university sector has taken more steps to maximise the funding it receives through SRE than JRE. The stated intention of JRE might be being compromised by the lack of a recognition structure for engagement with industry and the broader community, as discussed earlier. Two other factors are also likely to be affecting its effectiveness as a stimulus for behavioural change:

- Category 1 income includes a range of competitive grant programs that are primarily focused on end-user research—for example, programs administered by the Rural Research and Development Corporations.
- The funding formula for JRE continues to include the number of publications (primarily seen as an indicator of research excellence) and the student load as criteria (see Appendix A).

This approach creates mixed signals for the sector and makes it more difficult for universities to develop strategic plans that align with the objectives of government funding. The change from the Institutional Grants Scheme to the JRE Scheme has also removed the idea of a dedicated stream of funding to provide base support for research activities.

The United Kingdom offers an interesting example of what can be achieved with a dedicated stream of flexible funding to support greater engagement. Since 2001 it has provided funding under the Higher Education Innovation Fund to support and develop a broad range of knowledge-based interactions that result in economic and social benefit.

Analysis results released early in 2014 found that the HEIF funding has been crucial to supporting engagement between higher education institutions and external users. Every £1.00 of HEIF funding received in the period 2003 to 2012 is associated with approximately £6.30 of gross additional knowledge exchange income in that period. This figure probably represents an underestimate of the total benefits, however, because of the potentially large impacts that are hard to capture as well as the long-term benefits arising from the positive behavioural and attitudinal changes towards knowledge exchange it has promoted among academics (Ulrichsen 2014).

HEIF funding is provided on the condition that institutions submit a plan for how they will use the funding to support knowledge transfer. For the most recent allocation, the Higher Education Funding Council of England was supported in its assessment of the institutional strategies by specialist economic consultants Public & Corporate Economic Consultants. HEFCE and the consultants noted the high quality of the strategies submitted, including the increasing integration of knowledge exchange into the higher education institutions' own missions and the range of innovative practices being adopted (HEFCE 2008).

It should be noted that this approach was adopted after a degree of experimentation with the program settings and broader policy settings that are complementary, as well as time to embed the cultural changes. The commitment to research and innovation and pioneering new approaches to increase the benefit to the United Kingdom has been a feature of policy under both the previous Labour and the current Conservative governments.

In Australia, the recent National Commission of Audit report recommended streamlining the current system of research block grants and looking at options for better aligning funding for the direct and indirect costs of research (Shepherd et al. 2014). If this recommendation were adopted, there would be benefit from also considering how to create clearer links between the funding formulae and the stated purpose of the scheme. This would also aid in performance monitoring, as the Australian National Audit Office has recommended (ANAO 2014). It is, however, important that any changes be subject to detailed consultation, so that the strengths of the current system are not lost and support for a broad base of research effort in the university sector continues.

5.3.3 Strategic funding

Beyond competitive and block funding, governments also support research through strategic funding, which is usually tied to specific priorities. As noted, a number of processes being used in comparator countries are taking a more interventionist approach to funding in priority areas.

These processes are highly consultative and rely on experts to assist with understanding the level of current effort, gaps in or barriers to improved outcomes, and the appropriate mix of funding. For example, Innovate UK has a suite of interventions it can use that take into account the unique circumstances of specific sectors and ensure cohesive and coordinated support.

It is important to note that strategic funding processes can have competitive and non-competitive mechanisms. For example, Innovate UK's support for its transport priority area in 2013–14 includes a Catapult centre, collaborative R&D competitions, and feasibility studies in specific areas as well as connecting the public sector as a 'lead customer' with innovative companies (Innovate UK 2014a). One strength of this approach is that it leverages other funding mechanisms and support structures both domestically and internationally. The approach is reliant on a flexible source of funding and a high degree of independence and expertise.

Although some processes in Australia have taken a more strategic approach, in general they have been small in scale and have not been sufficiently flexible to take advantage of the effort in other parts of the research system nationally and internationally. One exception is the National Collaborative Research Infrastructure Strategy, or NCRIS, which provides a clear example of the benefits of a strategic and consultative approach to priority setting and resource allocation (Department of Education 2014c).

By their nature, strategic processes need to go beyond the university sector and include all the players in the research system to ensure the best results. What characterises those countries that are the top performers in research is the inclusion of key players in the development of national research policy. Universities, however, have a unique role to play in providing the skilled researchers and the diverse research expertise needed to deliver on the stated goals.

5.4 Research workforce

A skilled research workforce is essential. Development of research graduates is a task performed by the university sector and constitutes one of the fundamental features of the sector's role in the research system. Many studies have found that recruitment of skilled graduates is the most important mechanism whereby businesses derive economic benefit from publicly funded research (Salter & Martin 2001).

In Australia, concern has been expressed about the 10 per cent reduction in Research Training Scheme funding and the introduction of fees for higher degrees by research announced in the 2014–15 Budget. A skilled research workforce is a prerequisite for a productive knowledge economy, and this principle has been reflected in the exemption of student contributions towards the cost of a higher degree by research. Although research students will be able to defer payment through the Higher Education Loan Program, there is a risk that the fees will act as a disincentive. In addition, the cumulative effect of the new fees for higher degrees by research, debt acquired through completing an undergraduate degree in a deregulated market and the higher interest rate could lead to a reduction in the number of students undertaking postgraduate research.

Research students are the engine room of Australia's research and innovation capacity. A drop in the number of such students could lead to a reduction in Australia's research workforce capacity and this, in turn, is likely to adversely affect the nation's research performance. Of course, universities can choose not to charge the fees, but the government still expects the same number

of research students to be trained. The reduction in funding would have to be borne somewhere else in a university's budget, international and domestic student fees being the most flexible item.

There has been a longstanding government commitment to review the Research Training Scheme. The initial phases of review began in 2011 with a consultation paper that aimed to identify what quality in research training means and how it can be measured and encouraged. The recent paper *Boosting the commercial returns from research* (Department of Education and Department of Industry 2014) states that research training arrangements will be reviewed, with a particular focus on the issue of industry relevant training.

The most recent detailed analysis of factors affecting Australia's research workforce was carried out in order to develop the previous government's research workforce strategy (DIISR 2011). It was found that our research workforce is concentrated in academia and is considerably older than the professional workforce as a whole. Domestic students' uptake of postgraduate research degrees rose by only about 1.2 per cent a year between 2001 and 2012 (Department of Education 2014a). The academic research workforce is increasingly engaged through contracts, and the conditions of employment are seen as the main reason for leaving the profession. All these factors combine to present significant risks for Australia in meeting its research workforce needs, especially if we hope to move to a knowledge-based economy.

A matter of ongoing concern in the Australian system is the career path for researchers. The overwhelming majority of research staff in universities are on fixed-term contracts, and opportunities to move to a permanent appointment are limited (Broadbent et al. 2013). Universities need to look at ways of providing a clearer, more reliable career path for researchers, both in academia and in the broader workforce.

The recent announcement of ongoing funding for the Future Fellowships Scheme, albeit at a smaller scale and restricted to Australian researchers, is a welcome initiative to help universities provide longer term appointments. The balance in the distribution of fellowships at different points in a researcher's career is, however, an area that would benefit from further consideration.

In the current system there are also considerable disincentives for researchers wanting to spend time outside academia during their career. The lack of researchers employed in industry is seen as one of Australia's primary weaknesses in terms of improving the nation's innovation performance because it reduces industry's absorptive capacity to apply cutting-edge research and technology. The UK Wilson review of business–university collaboration placed great emphasis on the role of student and staff mobility in fostering cultural change and promoting greater links (Wilson 2012).

Improving the range of more generic skills—such as communication, project management and entrepreneurship—is also seen as an important part of improving graduates' industry readiness. This would, however, require looking at the current structure of the PhD in Australia in terms of length and assessment. Australia could look internationally, to initiatives such as Denmark's Industrial PhD Programme and Malaysia's Industrial Attachment Programme. Both of these initiatives are designed to improve graduates' employment readiness by requiring PhD students to spend some of their candidature working in industry. The Industry Doctoral Training Centre is a new Australian approach that is also relevant.

There is, however, also a fundamental question about how to increase the level of demand for research skills in Australian businesses. Small initiatives have been introduced to increase demand—for example, the Researchers in Business grants under the Enterprise Connect program—but a lack of scale and reliability limits their ability to engender widespread cultural change. Industry needs programs to be consistently available if they are to build them into their planning. Improving the perception of the value of a research-skilled workforce is also central to increasing demand.

5.5 Research infrastructure

High-quality research infrastructure is one of the fundamental requirements for producing excellent research. Australia has created world-class national research infrastructure that is widely accessible and cost-effective as a result of collaborative and strategic resource allocation. The principles and procedures applied under the National Collaborative Research Infrastructure Strategy are recognised as offering a highly effective way of increasing the strategic impact of dollars invested. The Strategic Framework for Research Infrastructure Investment expands these principles and consolidates the insights from NCRIS and related policy work.

The research sector showed considerable maturity in the NCRIS process and assisted the government to determine the priority areas for investment. The additional lens of choosing investments that would achieve a significant improvement in Australia's capability (as opposed to incremental improvement) was also crucial to the outcomes achieved. By seeking to meet the needs of a broad base of users—rather than a single institution or discipline—NCRIS facilities are supporting novel, collaborative research activities (Department of Education 2014f).

However, the subsequent allocations of funding for national research infrastructure have only followed some of the principles described in the strategic framework, with stop-start allocations of funding and limited funding for operational costs. Holistic funding for national and landmark-level research infrastructure is imperative if we are to ensure efficient, productive and viable facilities. In particular, funding for specialist staff allows greater ease of access for industry and results in superior service delivery.

The folly of providing capital-only funding was highlighted in a UK House of Lords Science and Technology Committee report released in 2013. The committee found a 'damaging disconnect' and recommended that the government review the situation to make sure capital investment and funding for operational costs are tied together in one sustainable package.

One example cited in the report concerns the ISIS research facility in Oxfordshire, a world-leading base for neutron research. ISIS cost £50 million to build and has recently doubled in size as a result of a government-funded £145 million investment. Despite this, witnesses told the committee there was not the budget available to run the site at full capacity and that it was being used at only two-thirds of its potential. This resulted in hundreds of potential experiments not being conducted, industrial projects losing out, and a missed opportunity for UK research (House of Lords Science and Technology Committee 2013). There are strong parallels between this example and important Australian facilities such as the Synchrotron.

The additional funding of \$150 million for NCRIS for one year, as announced in the 2014–15 Budget was welcomed by the sector, although it is hoped that the planned review will lead to a commitment to ongoing funding at a higher level and a return to the consultative and strategic process of allocation that led to the development of these excellent national facilities. Because of the increasing importance of multidisciplinary approaches, it is likely that in the next phase of development greater integration of facilities will be necessary to provide researchers and industry with the tools they need in a seamless manner.

In addition, the issue of operational funding for Landmark facilities—such as the Open Pool Australian Lightwater reactor and the RV Investigator—will also need to be addressed. Since these facilities are primarily hosted by government research agencies such as CSIRO and ANSTO, there will need to be a high degree of cooperation between the Education and Industry portfolios to ensure there is no policy disconnect leading to inconsistencies between the approaches taken.

5.6 Domestic and international collaboration

Strong collaboration, both domestically and internationally, is a feature of high-performing research systems. Researcher-to-researcher collaboration is increasing in Australia and internationally. International co-authorship of publications increases the citation impact of the research, but Australia ranks only 26th out of 42 OECD countries for international co-authorship (OECD 2014).

Other dimensions of collaboration also call for consideration. For example, there is some debate about the best method for supporting collaboration between research organisations and the end-users of research, including industry. The previous government supported the creation of ‘Industry Innovation Precincts’, but this program was abolished in the 2014–15 Budget. A geographic approach to cluster development could be problematic in a country such as Australia, with its large land mass and dispersed population. The most successful clusters internationally have developed not through top-down government intervention but have been supported by framework conditions that foster cluster development.

The future of the Cooperative Research Centres program, a longstanding scheme that supports collaboration with end-users, is not clear. It is currently being reviewed, and \$80 million in savings over the forward estimates was announced in the 2014–15 Budget. In the program’s reduced state, the opportunity cost for applicants could become too high and the ability to deliver on program objectives is likely to be compromised.

The Australian Research Council’s Industrial Transformation Research Program, a relatively new initiative (announced in 2011), was at one time expected to be linked to the Industry Innovation Precincts. The time frames for the application procedures have thus far been short, and this might have hampered universities’ efforts to build deep relationships with their partners. University–industry collaboration requires time and trust to ensure success, and stability in the policy direction is needed if industry partners are to embrace the program.

This stability is a feature of the Rural Research and Development Corporations. The model has been in place for more than 20 years and has been very effective for the agriculture sector. It might, however, be less applicable to other sectors of the economy where there are fewer common research problems among industry partners.

Senior staff in universities have a clear role to play in encouraging collaboration with industry. If the range of issues highlighted in this chapter—such as incentivising engagement, promoting workforce mobility, and increasing the visibility of available expertise—are to receive an adequate response, institutional ‘champions’ and a strong commitment to change are necessary.

Supporting links between research organisations to achieve a particular outcome is another aspect of domestic collaboration. Funds for the majority of relevant programs in Australia are allocated on a competitive basis. In keeping with the discussion on strategic funding mechanisms earlier in this chapter, benefit could arise from creating greater critical mass in areas of priority or competitive advantage through strategic collaboration funding, as part of a suite of interventions.

International collaboration is necessary if Australia is to achieve its international objectives and improve its competitiveness. Universities have developed considerable links internationally, and researcher-to-researcher collaboration continues to grow. Notwithstanding this, if Australia is to build enduring relationships such efforts must be coordinated and strategic so as to increase the scope and impact of the nation’s research and science efforts.

Australia has two dedicated funding programs to support international science collaboration—one with India and one with China. These are important initiatives, but the lack of any funding to support science relationships with other countries is giving rise to missed opportunities for collaboration at a strategic level with leading research countries. For example, Australia has no overarching strategy or flexible funding to engage with the European Union’s Horizon 2020 program. Horizon 2020 is the biggest EU research and innovation program, with nearly

€80 billion in funding available over seven years (2014 to 2020). Most of the priority areas under the program align strongly with Australia's areas of interest, and our domestic research effort could be greatly enhanced by increasing our links with the program.

International 'big science' initiatives also require national-level coordination if Australia is to take part. A prime example of this is the Square Kilometre Array. Without government support, Australia would not have been successful in its bid to host this ambitious project and would have missed out on the range of spill-over benefits to researchers and industry. An overarching international research collaboration strategy—accompanied by adequate ongoing funding—is needed if Australia is to be competitive in the future.

5.7 Access to publicly funded research

Internationally, there has been a push to improve access to publicly funded research. Many countries—including Australia, through the ARC and the NHMRC—have implemented open-access policies. Some countries have gone beyond specific policies for granting bodies, creating a dedicated system to improve the discoverability of research.

In the United Kingdom, for example, as part of the Innovation and Research Strategy, Research Councils UK has developed the Gateway to Research website to enable users to locate and examine information about publicly funded research. The website is intended to be of particular interest to innovative small to medium enterprises, facilitating access to information about current research projects and outcomes of past projects.

A similar initiative in Australia could help improve university–industry links and maximise the benefits from investment. It would also increase the visibility of the research undertaken in our institutions, both to other academics and to the general public.

5.8 Related policy considerations

Although they are beyond the scope of this document, a number of related policy considerations have an impact on university research and its performance, particularly in connection with university–industry collaboration. Policy changes that aim to encourage universities to collaborate with industry respond only to the supply side of the equation. In the absence of commensurate changes to support the demand side, it is unlikely these policies will have the desired effect.

A range of policies and programs exist to support businesses in being more innovative and in investing in research and development. There has, however, been a great deal of change in these initiatives in the past 10 years, which is not conducive to creating an environment in which businesses can rely on the availability of support. Constant change reinforces a view that investment in research and innovation is too risky. Australian businesses already have the lowest level of collaboration with higher education and public researchers in the OECD and are the fourth lowest collaborators for innovation (OECD 2013b).

Some excellent work has been done that points to possible ways ahead, including the work of the Australian Council of Learned Academies (Bell 2014) and the Office of the Chief Scientist (2014b). There are also numerous international examples that could be considered. Any interventions will, however, need to take account of Australia's industrial structure, which primarily consists of small to medium enterprises, with a limited number of multinational companies. Engaging with SMEs requires considerable support and an ongoing commitment, especially if we are to foster high-growth SMEs. Increasing the depth and breadth of entrepreneurial skills has been identified as another important factor.

The culture of Australian businesses and the value placed on research and researchers is also of concern. Reflecting on data on Australia's research workforce, university–industry collaboration and world-first innovation, the 2013 Australian Innovation System report noted:

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. (Department of Industry 2013, p. 116)

We need to move on from a transactional view of university and industry collaboration. A paper produced by the Big Innovation Centre with the support of the UK Intellectual Policy Office provides evidence of the need for active, long-term and multi-faceted engagement in order to achieve productive relationships between universities and industry (Anderson et al. 2013). The most successful relationships are built on a portfolio of different interactions involving research, education and training, staff placements and technology services.

In view of accelerating investment in research and innovation by our Asian neighbours and traditional competitors, Australia could be close to the proverbial 'tipping point', whereby we are not able to achieve our goal of a high-wage, high-growth economy.

A national strategy that addresses all facets of the system, targets both supply and demand, and includes long-term financial commitments is needed in order to bring about cultural change and improve Australia's research and innovation performance.

Appendix A Research block grants

Schemes

Research Infrastructure Block Grant Scheme

The Research Infrastructure Block Grant Scheme supports universities in meeting the indirect costs of their competitive grant research activity.

Sustainable Research Excellence Scheme

The Sustainable Research Excellence Scheme supports universities in meeting the indirect costs of their competitive grant research activities. In addition, it supports sustainable research excellence through the implementation of best-practice financial management, performance and reporting frameworks.

Joint Research Engagement Scheme

The Joint Research Engagement Scheme gives emphasis to end-user research by encouraging and supporting collaborative research activities between universities, industry and end-users, beyond those specifically supported by competitive grants.

Research Training Scheme

The Research Training Scheme provides support for the research training of domestic students doing a higher degree by research.

Australian Postgraduate Award

The Australian Postgraduate Award scholarships support postgraduate research by providing financial support to students of exceptional promise doing a higher degree by research.

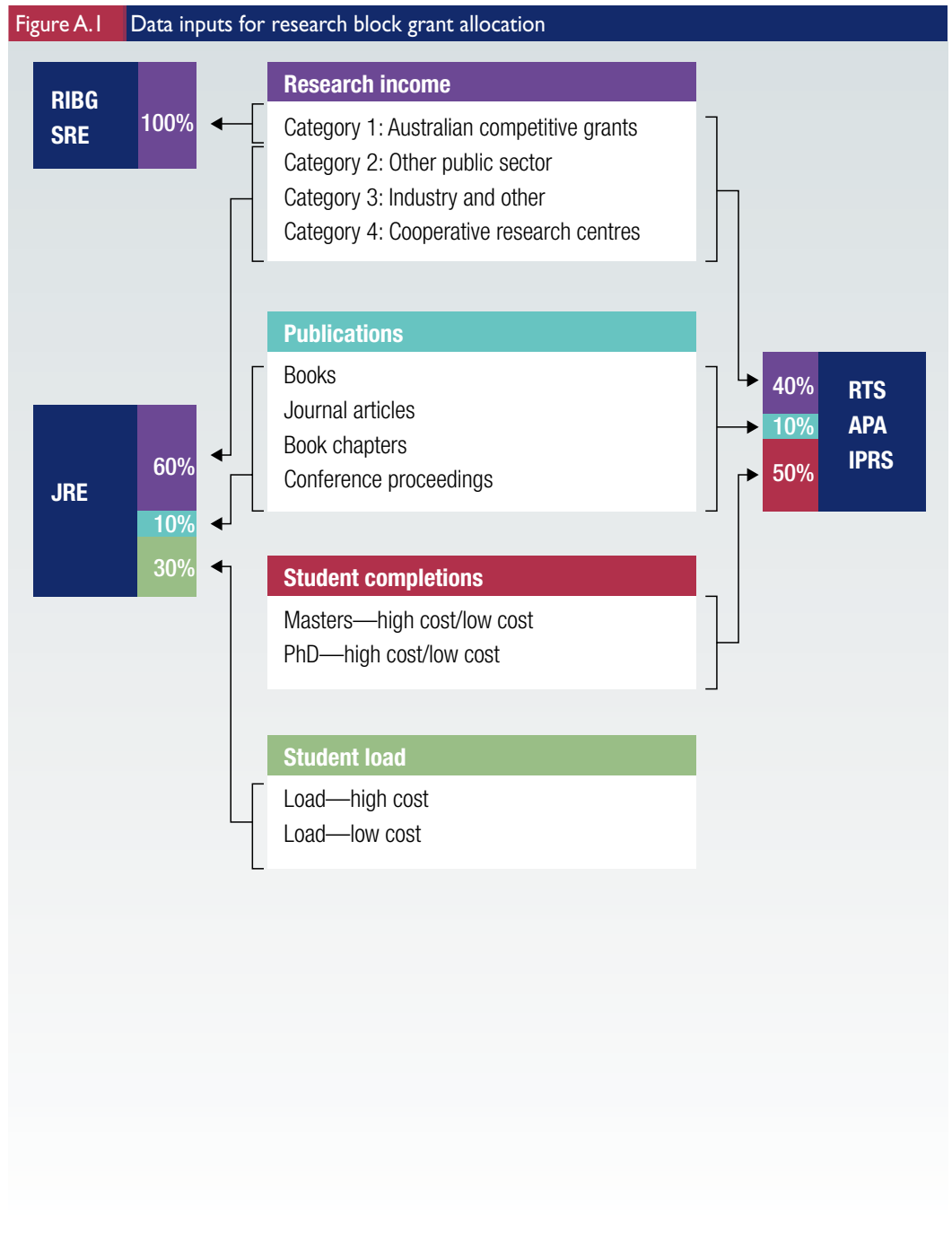
International Postgraduate Research Scholarships

International Postgraduate Research Scholarships support research excellence and research effort in Australia by attracting top-quality international research students to areas of research strength in Australian institutions. The scholarships cover tuition fees and health insurance costs for scholarship holders, as well as health insurance costs for the scholarship holders' dependants.

Calculation methodology

Grant amounts under the research block grant schemes are determined entirely by metrics. Data inputs are collected by the Department of Education through the Higher Education Research Data Collection, the Higher Education Student Data Collection and the Higher Education Staff Data Collection.

In addition, the Sustainable Research Excellence formula uses moderators based on data from the Research Hours Data Collection (Staff Hours Survey), the SRE Financial Data Return, and the Excellence in Research for Australia initiative. The Transparent Costing moderator is designed to recognise individual differences in the indirect costs of Australian competitive grant research between institutions, while the Excellence Index moderator is designed to recognise and reward research performance at or above world standard according to the outcomes of the Excellence in Research for Australia initiative.



Shortened forms

ABS	Australian Bureau of Statistics
ACOLA	Australian Council of Learned Academies
AIATSIS	Australian Institute of Aboriginal and Torres Strait Islander Studies
AIMS	Australian Institute of Marine Science
ANSTO	Australian Nuclear Science and Technology Organisation
APA	Australian Postgraduate Award
ARC	Australian Research Council
ARWU	Academic Ranking of World Universities
ATSE	Australian Academy of Technological Sciences and Engineering
BCA	Business Council of Australia
BERD	Business Expenditure on Research and Development
CRC	Cooperative Research Centre
CREATE	Campus for Research Excellence and Technological Enterprise
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DSTO	Defence Science and Technology Organisation
ERA	Excellence in Research for Australia
FoR	field of research
GDP	Gross Domestic Product
GERD	Gross Expenditure on Rresearch and Development
GovERD	Government Expenditure on Research and Development
GUF	general university funds
HDR	higher degree by research
HEFCE	Higher Education Funding Council of England
HEIF	Higher Education Innovation Fund
HERD	Higher Education Expenditure on Research and Development
HERDC	Higher Education Research Data Collection

HESDC	Higher Education Student Data Collection
IPRS	International Postgraduate Research Scholarship
IGS	Institutional Grants Scheme
JRE	Joint Research Engagement (Scheme)
MRI	Medical Research Institute
NCRIS	National Collaborative Research Infrastructure Strategy
NFP	not-for-profit
NHMRC	National Health and Medical Research Council
NRPs	National Research Priorities
OECD	Organisation for Economic Cooperation and Development
PPP	purchasing power parity
R&D	research and development
RCUK	Research Councils United Kingdom
RDCs	Research and Development Corporations
RIBG	Research Infrastructure Block Grant (Scheme)
RTS	Research Training Scheme
SME	small to medium enterprise
SRE	Sustainable Research Excellence (Scheme)

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