ERAWATCH COUNTRY REPORTS 2012: Australia

ERAWATCH Network – Pacific Innovation

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Acknowledgements and further information:

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Executive Summary

Australia is large: almost twice the size of Europe (EU27) but with 23 million people, less than 5% of the population of the EU27. The economy did not experience a recession due to the global financial crisis, although growth slowed to about 1.2%, rising to 3.3% in 2012. GDP per capita was about €52,000 (A$45,760) in 2012[1].

Australia is experiencing a resources boom. Almost 60% of exports are to East Asia. About 70% of Australia's trade was with the member economies of the Asia-Pacific Economic Cooperation forum. Resource commodities including coal and iron account for over 60% of Australia's merchandise exports in 2011. Other key exports are education services, tourism, motor vehicles and beef. The EU countries account for only about 15% of Australia's two-way trade; a level that is declining.

Research and Development (R&D) intensity was 2.2% in 2010-2011; higher than the 2009 EU27 level of 1.91%. The ratio of Gross Expenditure on R&D to Gross Domestic Product (GERD/GDP) has steadily increased from 1.47% in 2000-1. Business Enterprise R&D (BERD) accounts for about 58% of GERD; a proportion that has grown from 0.70% of GDP in 2000-2001 to 1.28% in 2010-2011 – a slight decrease from 2009-2010. BERD declined slightly in 2009-2010, due both to the financial crisis and to the pressure on manufacturing as a result of the high exchange rate, but recovered in 2010-2011. BERD/GDP however, declined from 1.38% in 2008-2009 to 1.28% in 2010-2011. Majority foreign owned firms accounted for almost a third of BERD in 2010-2011.

The incoming government in 2007 significantly raised public investment in research - particularly in universities - building on some substantial increases in research funding by the previous government. Australia has not experienced a recession due to the GFC, and although the growth in government funding is more restrained, Higher Education R&D (HERD) and Government Sector R&D (GOVERD) have continued to increase and new research initiatives have been introduced.[2]

The Innovation, Industry, Science and Research portfolio - with the Department of Industry, Innovation, Climate Change, Science, Research and Tertiary Education (DIISRTE) as its administrative and policy development core - accounts for the majority of research and innovation policy and funding. Following a review of the national innovation system in 2008 and subsequent new innovation policy framework in 2009, innovation and research policy has continued to develop through a range of consultative mechanisms and reviews of programmes and issues. The most recent major policy initiative has been the industry and innovation statement - *A Plan for Australian Jobs*, which responds to the report *Smarter Manufacturing for a Smarter Australia*, which focuses on short and longer term initiatives to support the manufacturing sector. As recommended in the 2008 review, a set of national innovation priorities has been established, setting out goals and benchmarks for research quality, linkages, innovation activity and international collaboration, and other dimensions of innovation system performance. Performance in relation to these priorities, and their goals and benchmarks, is reported annually in the comprehensive *Australian Innovation System Report*.

[1] The ECB €/A$ exchange rate ranged from 1.16 to 1.40 over the 12 months to mid-2013. A conversion rate of 1.25 is used here.

[2] For a brief summary of key statistics see *Australian Key Innovation Indicators*, Feb. 2013

The research system is pluralist and largely based on investigator-led research within a broad set of national research priorities. There has been a reluctance to develop strong strategies or mechanisms to support priority technologies or capabilities. There are a number of advisory and quasi-coordinating bodies at the national, inter-agency and sectoral levels. The dominant approach to international research collaboration is also bottom-up, although there is some prioritising in the case of some bilateral programmes with dedicated funding (e.g. China and India).

With some minor exceptions, sectoral policy is not a strong driver of research allocations. Technology priorities have also generally not been major drivers of research allocation, although some priority has been attached to enabling technologies, such as Information and Communication Technologies (ICTs) and biotechnology, and an *enabling technologies strategy* was announced in 2010. Clean energy technologies were a major focus of funding initiatives since 2008.

The long-standing R&D tax concession has not been a key driver of industry investment in R&D, but along with overall innovation policy, contributes to industry awareness. A revised scheme, based on a tax credit, has been introduced and aims to more effectively assist smaller and fast growing firms. BERD grew strongly for the decade up to 2008, but declined slightly in 2009-2010 and 2010-2011.

The characteristics and challenges of the Australian research system need to be understood within the context of the structure of the economy. Several characteristics are vital: the manufacturing sector is relatively small and even within that sector most industries are low to medium-technology level (in particular there are very few large research-intensive firms); the services and resources sectors are relatively large; and there is an important role played by Small and Medium Enterprises (SMEs). Partly as a consequence, Australia has a significantly lower proportion of researchers in the business sector (less than 30 per cent of all researcher person years of effort in 2008-2009) and a correspondingly large role in research by public research organisations. These characteristics are expressed in the pattern of innovation and research performance. Patenting and the allocation of innovation effort to new-to-the-world product innovations are towards the bottom of the OECD table. Much innovation in industry is focused on the modification and adaptation of technology developed in other countries. Conversely, academic/science performance, as indicated by publications, citations and international collaboration is toward the upper end of the range among OECD countries. Linkages between the research sector and industry are on the whole poor – with some exceptions. The evolution of the research and innovation system has led to quite strong research–industry links in the resource and agricultural sectors, but less so in many manufacturing and services industries. Several schemes support research–industry collaboration but have had only a modest impact.

If a resource industry cluster could be demarcated - including the mining, engineering, oil and gas industries and the manufacturing and service firms that supply them - this cluster would be the dominant research grouping in Australia.

The major fields of research in universities are medicine and other life sciences, while the dominant fields in industry are engineering and ICT. Graduates in Science, Engineering and Technology (SET) account for only about 20% of bachelor degree graduates. The recent growth in the resources industry and in the development of related infrastructure had led to significant skill shortages in engineering and mining-related disciplines.

The indicators of research-industry links and the direct commercialisation of public sector research, suggest a mixed performance. The proportion of HERD and GOVERD funded by business is in the top half of the OECD range, but indicators of the frequency of collaboration in the business sector are toward the bottom of the OECD range. Indicators of the commercialisation of public sector research through licencing and spin offs suggest a generally declining performance slipping below the rates of comparator countries.

In the context of long-term under-funding of universities, recent increases in research funding have focused on the higher education sector and have included greater support for competitive grants and fellowships and for infrastructure. Funding for HERD is about evenly allocated to competitive schemes and performance-based block funding.

A series of significant initiatives have strengthened the research system and put in place a more systematic foundation for policy and the allocation of funding. These initiatives include: the evaluation of university research performance through the *Excellence in Research for Australia* (ERA) initiative linked to the *Sustainable Research Excellence* (SRE) scheme aiming to drive investment into high performing research groups; the *Strategic Roadmap for Research Infrastructure* investment linked to substantial increases in funding for infrastructure; and the comprehensive *research workforce strategy*. The inflow of researchers from overseas is a vitally important mechanism for strengthening, if not retaining, the research workforce. The government's ambitious objectives for increasing the level of research will require a sustained growth in the research workforce that cannot be met by the current level of domestic supply. The inflow from overseas is largely through two channels: researchers recruited by research organisations and universities, and overseas students who remain in Australia after completing a PhD at an Australian university (currently more than 40% of such graduates remain in Australia). Overall about 50% of the stock of PhD qualified people in Australia were born overseas.

International research collaboration is an important component of research policy. Recent initiatives have increased support for collaboration and opened domestic research funding programmes to greater participation by non-nationals. However, there is little overall strategy to guide the development of international research collaboration, despite low levels of industry–research interaction. While research collaboration with the traditional partners in Europe and North America continues to expand, collaboration with India and particularly China is growing more rapidly.

Several recent research and industry capability initiatives have been in the area of environmental technologies, for example, the substantial increase in funding for the *Clean Energy Initiatives* and the earlier support for the Global Carbon Capture and Storage Institute (GCCSI). The introduction of a Carbon Tax in July 2012 may increase the availability of funds for further research into 'carbon-reduction' technologies.

Knowledge Triangle

	Recent policy changes	**Assessment of strengths and weaknesses**
Research policy	Excellence in Research for Australia (ERA) initiative linked to the Sustainable Research Excellence (SRE) to drive investment into high performing research groups. Development of a Research	+ Increase in funding for research and infrastructure. + Strong growth in international collaboration, particularly with the EU, China and India. + Extensive consultative mechanisms across states, ministries and departments.

	Workforce Strategy. Strategic Roadmap for Research Infrastructure investment. Introduction of a R&D tax credit aims to better support small high growth firms and to also encourage overseas investment into R&D. Research programmes opened to greater participation by overseas researchers, and most high-level fellowships are open. Development of 'compacts' covering strategic priorities across research, teaching and engagement with each university. Award of the SKA radio-telescope jointly to Australia/NZ and South Africa.	+ More strategic approaches to assessment, priorities and human resource development. + Research workforce strategy in place with consultative mechanisms for implementation. + Attractiveness to qualified immigrants. - Lack of an effective approach to building closer collaboration with users, - Lack of strategic approach to international research collaboration. - Mobility of researchers between industry and university is limited by the differences in incentive structure and performance assessment; in particular relatively low university salaries. - The research quality assessment framework (ERA) does not include any form of impact assessment.
Innovation policy	Launch of the Industry Innovation Precincts. Introduction of the National Enabling Technologies Strategy, including the development of for-sighting. Role of Commercialisation Australia in bringing together a number of earlier schemes to support early stage ventures. Further development of Enterprise Connect for SME capability development. Increase in funding for the Clean Energy Initiatives and other environment-related areas. The Industry Transformation Research programme to support closer research and education links between industry and universities.	+ Development of consultative councils and boards in many sectors. + Initiatives to strengthen capability in SMEs + Initiatives to increase support to high-growth SMEs - Lack of an effective approach to strengthening innovation linkages. - Fields of research in universities and in business are very different and the funding models do little to bridge that. - Lack of an agency to support applied research and closer research–industry links. - Lack of support for entrepreneur development programmes. - Growth of the resources sector drives structural change. - Social complacency regarding the development of new competences.
Education policy	The Bradley Review of Higher Education has resulted in increased funding to universities, plans to increase enrolments, and reduced regulation over student numbers. Initiatives to increase enrolments in Science, Engineering and Technology (SET) courses. New measures to encourage international students. Removing the limits on the levels of enrolment in universities and new measures to support participation by disadvantaged social groups.	+ Substantial increase in funding into the Education Investment Fund (now over €8b (A$10b)) will support investment in research and teaching infrastructure. + Planned increases in block grant research funding. - Long term decline in the level of government support per student. - Universities remain highly dependent on overseas students. - Universities face a complex set of performance requirements and strategic decisions as government policy seeks to drive greater differentiation around research emphasis and fields. - Generally poor working conditions for junior staff may lead to recruitment problems. - Low enrolments by domestic students in PhD courses in SET.
Other policies	The eligibility of foreign students and researchers to scholarships,	+ Science and society awareness programmes and initiatives.

	fellowships and research project funding has been widened.	+ New initiatives to link government procurement to business innovation. - Approaches to international research collaboration remain un-strategic, poorly funded and little evaluated. - Lack of an effective procurement policy, linked to innovation and capability development.

Assessment of the national policies/measures

	Objectives	Main national policy changes over the last year	Assessment of strengths and weaknesses
1	Labour market for researchers	Research Workforce Strategy and implementation mechanisms. Increased support for early career researchers. Substantial increase in funding for fellowships and postgraduate support. Opening of research fellowships and postgraduate support to non-nationals.	+ Strong immigration of qualified researchers; - Ageing research labour force; - PhD programmes not strongly attractive to Australian nationals.
2	Research infrastructures	Continuing investment in research infrastructure.	+ Consultative mechanisms and a national roadmap for infrastructure; + Approach to funding emphasises openness and an emphasis on shared facilities.
3	Strengthening research institutions	Substantial (25%) increase in government funding of research from 2008-2009. Continued strong increases in funding to universities through competitive research schemes and block grants.	+ Strong government budget support; + Primary reliance on bottom-up investigator led research. - Lack of strategic focus.
4	Knowledge transfer	The Industry Transformation Research programme. Industry Innovation Precincts.	+ A range of mechanisms to stimulate and support linkages and knowledge transfer. - Few effective incentives for collaboration with industry. + Stable programmes. - Lack of a flexible bilateral collaborative applied research mechanism. - Lack of a strategic orientation to industry collaboration. - Limited impact on the deepening of links. - Base funding of university teaching inadequate.
5	International R&D cooperation with EU member states	Continuing changes to research funding schemes to improve their scope to support international collaboration	-Little strategic focus. - Little assessment of the evolution and outcomes of collaboration. - Limited industry participation in collaboration.
6	International R&D cooperation with non-EU	As above. Bilateral meetings with government agencies from China and India with further development of collaboration	+ Strong growth in collaboration with China. - Little assessment of the evolution and outcomes of

	countries	mechanisms and funding.	collaboration. - Limited industry participation in collaboration.

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1 INTRODUCTION

The main objective of the ERAWATCH International Analytical Country Reports 2012 is to characterise and assess the evolution of the national policy mixes of the 21 countries with which the EU has a Science and Technology Agreement. The reports focus on initiatives comparable to the ERA blocks (labour market for researchers; research infrastructures; strengthening research institutions; knowledge transfer; international cooperation). They include an analysis of national R&D investment targets, the efficiency and effectiveness of national policies and investments in R&D, the articulation between research, education and innovation as well as implementation and governance issues. Particular emphasis is given to international research cooperation in each country.

2 PERFORMANCE OF THE NATIONAL RESEARCH AND INNOVATION SYSTEM AND ASSESSMENT OF RECENT POLICY CHANGES

2.1 MAIN POLICY OBJECTIVES / PRIORITIES, SOCIAL AND GLOBAL CHALLENGES

Australia has had one set of *National Research Priorities* for 10 years, although these are currently under review by the *Australian Research Committee*. It is intended that they provide a basis for focusing public funding on areas relevant to major economic, social and environmental challenges. There are four broad categories of these priorities and several specific priorities under each category: an environmentally sustainable Australia; promoting and maintaining good health; frontier technologies for building and transforming Australian industries; and safeguarding Australia. These priority areas are very similar to the 'grand societal challenges'. Most recent research initiatives have been in these four broad fields, with a particular emphasis on environmental initiatives: carbon capture and storage, biofuels and clean energy technologies.

Following the recommendations of a review of the national innovation system (Cutler, 2008) the government has specified a set of 'Innovation Priorities', set out in Table 1, aimed at improving the functioning of the 'innovation system'. These are effectiveness priorities concerning innovation system performance and are not related to the 'grand challenges'.

Table 1 Australia's Innovation Priorities

Priority	Goal
Public funding supports high-quality research that addresses national challenges and opens opportunities.	Increase proportion of world-class research
Australia has a strong base of skilled researchers to support the national research effort in the public and private sectors.	Increase higher degrees by research completions
The innovation system fosters industries of the future, securing value from the commercialisation of R&D.	Increase the number of businesses investing in R&D.
More effective dissemination of new technologies, processes, and ideas increases innovation across the economy, with a particular focus on SMEs.	By 2020, increase by 25% the proportion of businesses that innovate.
The innovation system encourages a culture of collaboration within the research sector and between researchers and industry.	By 2020, double collaboration between businesses, universities and PROs.
Australian researchers and businesses are involved in more international R&D collaborations.	Increase international research collaboration.
The public and community sectors work with others to improve policy development and service delivery.	Raise public and community sector innovation.

Source: Cutler, 2008: 141-147.

There has also been a strong emphasis on strengthening linkages within the innovation system (a weakness consistently identified in the assessment of the innovation system) and, to a lesser extent, international linkages.

2.2 STRUCTURE OF THE NATIONAL RESEARCH AND INNOVATION SYSTEM AND ITS GOVERNANCE

Australia covers 7.7m square kilometres, the sixth largest country in the world. The population in June 2013 was 23 million. GDP in 2012 was approximately €12300b (A$15375b) and has grown at about 3% over 2011-2012. GDP per capita is almost €52,560 (A$65,700) in early 2013. Australia did not experience a recession due to the financial crisis.[3] Minerals and petroleum account for the majority of exports, and the major trading partner - both for exports and imports - is China.

In 2010-2011, GERD was €24.7b (A$31b), 2.2% of GDP, having continued to grow for several years. BERD has grown from 0.62% of GDP in 1999-2000 to 1.38% in 2008-2009, but declined to 1.28% by 2010-2011. By 2010-2011 about 27% of GERD was performed in the Higher Education sector; 12% in PROs. The EU Member States are, collectively, the major research partners (based on joint publications) followed by the US and China. At an individual country level, the major partners, in order, are the US, UK and China.

Main actors and institutions in research governance

Policy and funding for R&D is pluralistic, with departments and agencies with functional responsibilities determining their own needs. The overall structure of the research system has changed little over the past 20 years, although the allocation of responsibilities at the departmental level does change from time to time. In 2008, administrative oversight of funding for research in universities and the Commonwealth Scientific and Industrial Research Organisation (CSIRO), and in 2011 overall responsibility for tertiary education, shifted from the education and training portfolio to the industry and innovation portfolio.

There is a range of coordination and consultation mechanisms. At the political level policy-making at Cabinet and Ministerial level is informed by a range of parliamentary committees - both in the House of Representatives and in the Senate - which conduct enquires, and by the Prime Minister's Science, Engineering and Innovation Council (PMSEIC), which can be influential in some policy issues[4].

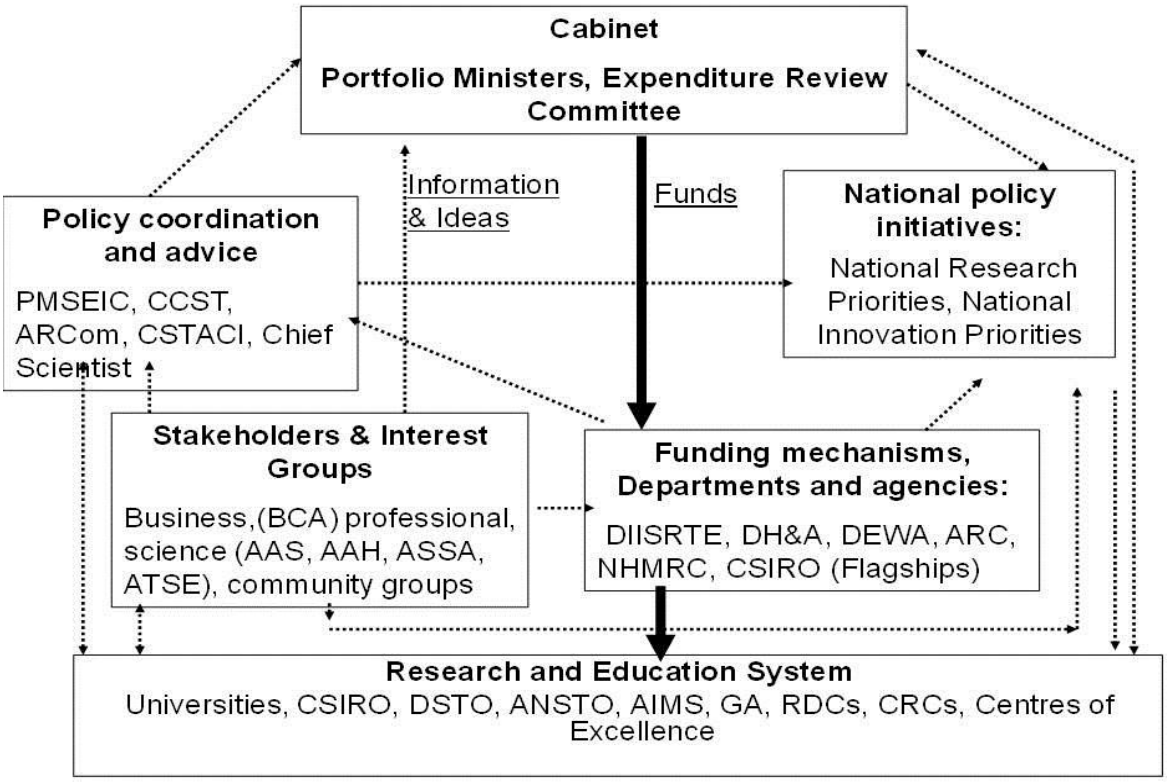
The key department in research policy and funding is the Department of Industry, Innovation, Climate Changer, Science, Research and Tertiary Education (DIISRTE), which has oversight of the CSIRO and the Australian Research Council (ARC). Other departments with significant research policy and management roles include the Department of Health and Ageing and the Department of Defence.

Figure 1 provides a high level structure of the research system, indicating the main flow of funds and the more extensive flows of information that support coordination and governance.

[3] Source: dfat.gov.au/geo/fs/aust.pdf

[4] Further information on the mechanisms for coordination and consultation are in Analytical Report, Australia - 2011

Figure 1: Overview of Australia's research system governance structure



The institutional role of regions in research governance

Australia is a federation and the role of the six States and two Territories is circumscribed. They have a primary role in basic services and policy, e.g. for non-tertiary education, health and policing. Most States (and Territories) have become more active in supporting research and collaboration, and most have policies for industry development and innovation, and some form of Innovation or Science Council. Nevertheless, the total expenditure on R&D by State agencies accounted for only 4.7% of GERD in 2008-2009. Over half (55%) of GERD in 2008–2009 was conducted by firms and research actors located within two states, NSW and Victoria (see *ERAWATCH Research Inventory, Australia Country Fiche 2011*).[5]

2.3 RESOURCE MOBILISATION

2.3.1 Financial resource provision for research activities (national and regional mechanisms)

Australia's GERD (€24.7b (A$31b) and 2.2% of GDP in 2010-2011) grew at over 6% per annum from the mid-1980s to 2008. Over that period BERD had grown at 9.4% per annum. While there has not been an explicit target for GERD, BERD or expenditure on education, policy documents compare Australian performance with the 'OECD average' and the top performers in the OECD. GERD/GDP has increased from 1.43% in 1998-1999 to 2.2% in 2010-2011.

The distribution of Commonwealth government research funding is complex. There are four sets of funding instruments: block grants to universities; major competitive funding schemes for universities (and independent medical research institutes); budget allocations to PROs; and an array of more targeted competitive research

[5] Further information in the role regions is in Analytical Report, Australia – 2011

funding schemes. About 21% of Commonwealth funding is 'allocated' to the business sector through the R&D tax concession (hence, it is actually tax revenue forgone), and also through some competitive grant schemes. About 20% goes to support the PROs, largely on the basis of negotiated three-year funding agreements. The major funding channels for the higher education sector account for over 50% of Commonwealth R&D support.[6]

BERD in 2010-2011 was €14.30b (A$17.9b); an increase of only 3% since 2008-2009. However, BERD had been growing at 15-20% over 2005-2008, taking the BERD/GERD ratio to 1.38% in 2008-2009 (1.28% in 2010-2011), a level above that of the UK, Canada and the Netherlands, and similar to France.[7] Raising the level of BERD has long been a policy objective.

Competitive vs. institutional funding and national research priorities

The main funding bodies are identified in Section 2.2. Change in research policy is based on periodic reviews and policy statements, such as in Powering Ideas: An Innovation Agenda for the 21st Century, announced in mid-2009. Commonwealth funding for the universities is almost equally divided between performance-based block grants and competitive project-based funding. Universities also gain research funding through the CRC Programme, the Rural Research and Development Corporations (RRDCs) and other schemes. The outcomes of the recent development of more systematic assessment of research quality will become a criterion for the performance assessment for block grants to universities – but at this stage accounts for only a small percentage of the block grant funding. In practice, due to the importance of publications in highly-ranked peer-reviewed academic journals, amplified by the current research assessment approach, the competitive funding schemes tend to drive much of intra-organisation allocation of the block funding. This is exacerbated by the lack of diversity in research funding mechanisms and the absence of any overall strategic innovation-linked approach to research funding.

The Collaborative Research Networks (CRN) Programme was established in 2009 to link through collaborative research, regional or less research intensive universities with major research universities. In 2011, funding of €47.3m (A$59m) was provided for research projects from 2011 to 2014, and in 2012 the programme was widened to further participants.

Recent Policy Developments in Response to Policy Reviews[8]

In November 2011 the response to a review of public sector research support was provided in the report *Maximising the Innovation Dividend: Review Key Findings and Future Directions*. The review found no evidence of significant shortfalls in the current framework for publicly funded research, but saw a need to clarify the roles of the participants in the research system. The statement recommended that an improved evaluation be developed to show the social benefits of publicly funded research and provide greater confidence in the value derived from public investment in research and that new mechanisms are needed to encourage universities to more effectively engage with industry. A €192m (A$240m) *Industrial Transformation Research Programme* announced in December 2011, largely focused on human resource development, included support for new 'research hubs' that will aim to link researchers and industry for innovation and problem solving - up to 20 research hubs

[6] For further detail see the Australian country fiche.

[7] *ABS Research and Experimental Development, Businesses, Australia, 2010-11. Cat 8104.0*

[8] The 2009-10 Commonwealth Budget included a major boost for research – see Analytical Report, Australia – 2011

with initial funding of up A$1m for up to four years. In May 2012, a €23m (A$29m) *Manufacturing Technology Innovation Centre* was announced which aims to bring together researchers and manufacturers to drive innovation. In February 2013 an industry and innovation statement - *A Plan for Australian Jobs* - announced €800m (A$1b) over five years in largely new funding for a range of initiatives to boost Australian participation in major projects and to create up to 10 Innovation Precincts that aim to raise the level of research-industry collaboration for innovation and to leverage the ARC's Industrial Transformation Research Programme funding. The statement was in large part a response to the report of the Prime Minister's Task Force on Manufacturing, *Smarter Manufacturing for a Smarter Australia*. The initiative also reflects the strategy laid out in the *Australia in the Asian Century* White Paper which set out a strategic approach for a strong orientation to growing and changing Asian markets.

Building Mutual Trust between Science and Society

In 2009, the Government commissioned the development of a strategy for a more cohesive, national approach to communicating the sciences. This led to the report Inspiring Australia - a national strategy for engagement with the sciences - and a new initiative in 2010 with €15m (A$19m) funding over four years to develop and implement a strategic approach based on a closer partnership between governments, agencies, organisations and communicators active in communicating science to the community. The initiative aims to develop a scientifically engaged Australia, which values scientific endeavour, and to increase national and international interest in Australian science.

Grand Challenges

Research collaboration, both intra-national and international, is promoted in all areas of research. However, it is particularly encouraged either in areas of basic research (for example *space*, and particularly the major radio-astronomy facility - the *SKA* - in which Australian participation was announced in 2012), pre-competitive research (where there is a strong emphasis on building research capacity,for example the *National Enabling Technologies Strategy*, (DIISRTE, 2010g)), or in areas such as climate-related initiatives where the costs are high and the benefits likely to be widely shared (for example the *Clean Energy Initiative* (CEI) including the *Carbon Capture and Storage Institute*). The *Australian Solar Institute* (ASI) was formed to facilitate collaboration, particularly domestic collaboration; In December 2012 the ASI was merged into the *Australian Renewable Energy Agency* (ARENA).

2.3.2 Providing qualified human resources

The overall engagement of human resources in R&D (Table 2) has grown strongly over the nine-year period 2000-2009, particularly in the business sector (almost a 100% increase), followed by the Private Non-Profit (almost 70% increase) and then the Higher Education sector (almost 30% increase). The available data indicates that these trends continue, even when the R&D expenditure has declined, as in the business sector. The R&D human resources in the Government sector (i.e. State and federal PROs) actually declined. In absolute numbers, the Higher Education sector remains the dominant employer of research personnel, accounting for 45% of the human resources devoted to R&D in 2008-2009. This proportion is likely to grow further due to the strong growth in support for research in the higher education sector. Human resources in science and technology (HRST) as a proportion of the

workforce (35% in 2010[9]) is similar to many EU countries, but the estimated percentage of women in HRST (37%) is lower than in most EU countries.

Table 2. Gross Human Resources (PYE) devoted to R&D, by sector

Person Year Effort	2000-01	2008-9	2010
Business	28,391	53,556	57,500
Comm. Government	9,565	9,209	
State Government	8,587	7,834	
Higher Education	46,287	61,310	69,200
PNP	2,792	4,788	
Total	95,621	136,696	

Source: ABS, 2010b, 2011, 2012

In 2001 (the most recent comprehensive data), 21% of the population aged 15 years and over, had an advanced diploma, bachelor degree or higher degree and/or was employed as specialist managers or professionals. Such people were most commonly employed in the education (22%), property and business services (20%) and health and community services (19%)[10].

After a series of reviews and extensive consultation, the government release a new research workforce strategy - *Research Skills for an Innovative Future* - in 2011.

Knowledge Triangle Policy Linkages

A number of initiatives have sought to develop industry-relevant skills in research students while also strengthening links between business and universities[11].

Main Societal Challenges

Sustained growth in the resources and related sectors has led to skill shortages in many engineering, technical and trade categories, and rising salaries. As a result, the incentive to undertake PhD research with a view to a research career has weakened. Australian Universities, PROs and businesses actively recruit researchers from all countries on the basis of merit.

Concerns about the low proportion of SET graduates were reviewed in a recent assessment of the health of Australian science.[12] The report found that domestic undergraduate enrolments had grown strongly in Health (73% growth over 2002-2010, modestly in Engineering (21%) and the Natural and Physical Sciences (29% in recent years after flat-lining for several years), but declined in Information Technology (-50%) [13]

Concern regarding 'employability skills' (also termed generic of soft skills) has been developing since the 1980s, with strong advocacy by industry groups over the past ten years. Entrepreneurship education has had a surprisingly slow start in Australia

[9] Estimate in *OECD Science, Technology and Industry Scoreboard 2011* – detailed ABS survey data is not available later than 2001.

[10] *8149.0 - Human Resources by Selected Qualifications and Occupations, Australia*, 2001 Further information is in Analytical Report, Australia – 2011

[11] See Recent Policy Developments, above and for further information see Analytical Report, Australia - 2011

[12] Further background to this issue is in Analytical Report – Australia, 2011.

[13] Office of the Chief Scientist (2012) *The Health of Australian Science*. Skill shortages, particularly in engineering and technical areas have become a major constraint on growth in some sectors. These issues were examined in the 2012 report: *Senate Committee The shortage of engineering and related employment skills*

(Chan, 2005). From the early 2000s a growing number of universities were offering entrepreneurship within undergraduate and postgraduate programmes. By 2010 almost all university business programmes included an entrepreneurship option and a half of the universities offered specialist undergraduate or postgraduate degrees. Nevertheless, the development of Entrepreneurship programmes, of the US style, with extensive links to regional entrepreneur communities, has been much more limited. There has been no central support for the development of entrepreneurship education. There are some examples of entrepreneur development initiatives supported by successful entrepreneurial business people.

2.3.3 Evolution towards the national R&D&I targets

There has been a long-standing policy of encouraging private sector investment in R&D. The primary policy instrument, introduced in the early 1980s, has been a tax concession for eligible expenditure on R&D – now replaced by a tax credit scheme. This entitlement policy regime has been neutral with regard to sectors.

Expenditure on R&D by Australian businesses in 2010-2011 was €14.3b (A$17.9m) (see Table 3). BERD as a proportion of GDP increased from 1.26% in 2007-8 to 1.28% in 2010-11. In 2010-11 almost all (96%) expenditure for R&D by the business sector (BERD) was spent within the business sector. BERD declined slightly in 2009-2010, due both to the financial crisis and to the pressure on manufacturing due to the high exchange rate, but, like the EU-27, grew strongly in 2010-2011. BERD/GDP however, declined from 1.38% in 2008-2009 to 1.28% in 2010-2011.

Table 3. Business resources devoted to R&D

	2005-06	2006-07	2007-08	2008-09	2009-10	2010-11
Expenditure on R&D €m	7,616	9,226	10,881	13,280	12,830	14,304
Expenditure on R&D A$	10,434	12,639	15,047	17,264	16,685	17,880
Annual Growth % (nominal)	20	21	19	15	-3	7

Source: ABS, 2010c, 2011, 2012

Policies to raise the BERD/GDP level have been followed for several years, but there has also been recognition that the level in part reflects the structure of the economy. This is for two reasons: first, the major Australian industries (services, mining and resource processing) are not (or have not been) research-intensive; and second, many of the manufacturing sectors that are typically research-intensive in the EU (i.e. pharmaceuticals, electrical and electronic equipment, aerospace, automotive) are dominated by the branch plants of foreign-owned firms in Australia. Manufacturing (27%) and Mining (21%) were the largest contributors to BERD in 2010-2011. Financial and insurance services (15%) and Professional, scientific and technical services (15%) were the next largest contributors. These four industries combined accounted for almost 80% of total BERD. If a resource industry cluster could be demarcated, including the mining, engineering, oil and gas industries and the manufacturing and service firms that supply them, this cluster would be the dominant research grouping.

In 2010-2011, businesses with >200 employees made the largest contribution to BERD (68%) and businesses with 20–199 employees accounted for a further 19%. Small firms (<19 employees) have shown strong increases in R&D over recent years. In the 2009-2011 period firms with less than five employees showed the greatest growth in R&D.

The business sector was the main source of BERD funds with over 96% coming from own funds. Other sources were: 2% from other business; 2% from Commonwealth government and 1% from overseas sources.

Wholly Australian owned businesses made the largest contribution to BERD (58%) and were the only group recording an increase from 2008-2009. Minority foreign-owned businesses (10-50% foreign ownership) accounted for 8% of BERD in 2009-2010 and majority foreign-owned businesses accounted for 29% - both had a declining level of R&D and share of BERD from 2008-2009.

Funding from business enterprises accounted for 4.1% of HERD in 2010; a decline from the 5.7% in 2004-2005. This decline is in part due to the increase in Government funding of university research and research infrastructure. Funding from business enterprises accounted for 5.5% of GOVERD in 2008-2009.

Policy Mixes to Encourage Private R&D Investment

Encouraging greater business enterprise investment in R&D and innovation has been a long-standing policy objective - pursued largely through fiscal policy - although there are no explicit GERD or BERD targets

An *R&D Tax Credit* scheme has been introduced to replace the R&D Tax Concession, following the recommendations of the Review of the National Innovation System (Cutler, 2008). The R&D Tax credit has two components: a 45% refundable tax credit (equivalent to a 150% concession) available to firms with an annual turnover of less than €14.5m (A$18.1m); and a 40% non-refundable tax credit (equivalent to a 133% concession) available to firms with an annual turnover of €14.5m or more. However, from July 2013, firms with turnover in Australia greater than €16b (A$20b) will no longer be eligible for the concession.

- Greater R&D in R&D performing firms BERD has increased at relatively high rates over the past 10 years, driven largely by the increase in R&D in larger firms.
- Increasing the number of R&D performing firms: The number of firms investing in R&D has increased more slowly. The number of businesses registered for the R&D Tax Concession increased 6% in 2010 from 2009; increasing the number of 'innovation-active' businesses by 25% over 2007-2017 is an 'innovation priority'. Since 2007–2008 the proportion of innovation-active businesses in Australia has varied, dropping to 39.8% in 2008, climbing back to 44.7% in 2009 but falling to 39.1% in 2010. Long-term trend data suggests a positive, low annual growth rate in the proportion of innovation-active firms (~0.7% per year).[14]
- Promoting new R&D performing firms: most earlier schemes have been replaced by the more direct granting mechanisms of *Commercialisation Australia*.[15] Current immigration policy encourages 'business migrants' (people with business experience and bringing significant capital) and entrepreneurs (individuals with an entrepreneurial track record and a new business proposal). The 2013 Industry and Innovation statement, *Plan for Australian Jobs*,

[14] DIISRTE, Australian Innovation Systems Report, 2011; Australian Innovation Systems Report, 2012.
[15] For details see ERAWATCH Research Inventory, Australia Country Fiche 2011 and 2012 at http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/

included additional funding for venture capital and assistance for management development focussed on high growth firms.

- Attracting R&D from overseas firms: there has been a long standing strategy to attract R&D performing firms from abroad, and to retain the R&D activity from international firms within Australia. No systematic analysis is available, but the strength of R&D in the mining sector in Australia has attracted some international firms to locate or increase R&D activity in Australia. [16]
- Increasing extra-mural R&D: the nominal value of funding from business enterprises for R&D in the Higher Education sector accounted for only 1.9% of BERD (and 4% of HERD) in 2010. In 2010 business funding as a proportion of HERD declined from 5% to 4.1%. Only 1% of BERD in 2008-2009 was allocated to expenditure in PROs. Business funding of university research grew strongly from the early-1990s, and while the absolute level of funds has grown, the share of HERD has not. The various policies that have sought to encourage closer research links between business and universities, and between both and PROs, have had some limited success, but have not been transformative.
- Increasing public sector R&D: funding for the two major competitive research schemes increased significantly; the NHMRC more than doubled (in real terms) over 2002-2013, and ARC funding doubled in nominal funding over this period.

These various initiatives are designed to be accessible and there is a great deal of information available to inform organisations seeking support. The overall policy-mix is broadly effective in supporting gradual progress. However, any assessment of the appropriateness of the policy mix must come to terms with three issues. First, as noted above, due to the structure of the economy a good deal of innovative effort in firms is not formal R&D, so that mechanisms that focus on that part of the inputs to innovation may not be effective. Second, there is a growing range of mechanisms (none yet broadly effective) to stimulate and support industrial innovation-related research in universities. Third, due to the resource boom the economy is restructuring and some segments of manufacturing are continuing to decline.

Procurement and Innovation

The review of the national innovation system (Cutler, 2008) recommended a greater role for government procurement in fostering innovative firms and capabilities. Powering Ideas (2009), which was a response to this review, outlined what is essentially a continuation of current policy: incentives to include SMEs in the provision of IT goods and services to government agencies; and the Australian Industry Capability Programme operated by the Department of Defence which seeks to involve Australian firms in procurement of defence-related equipment.[17] A new €24m (A$30m) *Enterprise Solutions Programme* over five years - modelled on the *US* SBIR programme - was announced in the 2013 *Plan for Australian Jobs* to help SMEs bid for public sector work.

Other policies that affect R&D Investment

Australia is a very open economy with few restrictions on trade and investment. With the strong appreciation of the Australian dollar, due in large part to the rapid development of minerals and energy exports, the competiveness of many

[16] Scott-Kemmis (2011) Australian Story: the growth of Mining Equipment, Technology and Sector. United States Study Centre, University of Sydney.
[17] Further detail on procurement policies is in Analytical Report, Australia, 2011.

manufacturing and some service sectors has declined. With the exception of the automotive sector, where R&D support has been provided, no specific measures have been taken to protect these industries or to promote the retention or increase in R&D.

Human resource is an important R&D policy area. This includes both specifically researchers (which has been the focus of several recent reviews and initiatives) and the wider range of technicians, engineers and managers vital for innovation and production. Currently there are shortages in many fields and as a result immigration policy has been modified to enable higher levels of immigration in these fields.

The Innovation Systems Reports (DIISRTE, 2011, 2012) conclude that business conditions in Australia - including demand, competition and access to finance - compared reasonably well with other OECD countries. The reports found that although framework conditions for entrepreneurship were highly favourable, seed/start-up stages of venture capital investment were relatively low, and venture capital investment declined due to the global financial crisis.

2.4 KNOWLEDGE DEMAND

The structure of the Australian economy has a major bearing on the demand for knowledge, and structural change shapes the evolution of the research and innovation system (DIISRTE, 2010b). The key characteristics of this structure are:

- The relatively large contribution of mining and agriculture (both of which are becoming more knowledge-intensive) to GDP and the relatively low contribution of manufacturing;
- the dominance of low and medium-technology sectors within manufacturing;
- a small 'high technology' manufacturing sector accounting for less than 1% of GVA in 2005 (more recent data provides only sectoral breakdowns);
- a high proportion of foreign-ownership of industry - enterprises with greater than 50% foreign ownership accounted for 29% of BERD in 2010-11;
- a relatively small role of trade in GDP – smaller than in most smaller economies - and the high level of dependence on minerals in exports; and
- a relatively large proportion of small firms.

The main directions of recent change in the structure of the economy are:

- The sustained and continuing decline in the role of manufacturing, declining from almost 18% of GDP in 1978 to 8.7%% in 2010-11;
- the growth in knowledge-intensive business services to 25% of GDP in 2010; and
- growth in mineral exports, from 30% of exports in 1990 to over 60% in 2011, and a decline in the significance of manufactured exports from 26% of merchandise exports in 2006-2007 to 16% in 2010-2011 – although exports of instruments and specialised equipment have continued to expand.

As a result, the resources industries, particularly mining, have had a major and increasing role in the Australian economy. Knowledge demand is also shaped by the strong growth of R&D in the service sectors (which account for over 50% of BERD). There are few large research-intensive manufacturing firms in Australia.

The Australian Bureau of Statistics (ABS) collects detailed information on the field of research of R&D activity as well as the main sector of the enterprise. In 2010-2011 BERD was largely in the two research fields of Engineering, and Information & Computing Sciences (collectively 80%).

The modification of imported technology is a major focus of R&D in the business sector. Large Australian firms are more than twice as likely as small firms to focus their innovation on modifying and introducing to Australia innovations already developed internationally. Hence, large firms play a key role in knowledge transfer into Australia. [18] Investment in intangible capital (innovation-related activities such as skills development, design and organisational improvements) and multifactor productivity (the spill-over impacts of these intangible investments) together accounted for 62% of Australia's productivity growth between 1994–1995 and 2004–2005. Again, compared to other countries Australian firms are more than twice as likely to adopt existing technology embodied in physical machinery and equipment, than to invest in intangible innovation capabilities. However, average annual growth in intangible investment in Australia has been higher than tangibles investments for almost 30 years.[19] Australia has received on average about €25b (A$31.3b) of FDI inflows each year since 2001. The US dominates the stock of FDI in Australia accounting for 27% in 2011, followed by the UK (23%), Japan (6%), and the Netherlands (6%). FDI from China and India is growing steadily - China's FDI into Australia has grown almost 90 per cent per annum since 2006 (Sanyal, 2009).

The allocation of Commonwealth budget expenditure to 'energy, telecommunications and health' has increased over the past decade while the proportions of GBAORD allocated to 'Industrial production and technology' and to 'General University Funds (GUF)' have declined, markedly so in the case of GUF - although these two categories accounted for 37.8% of GBAORD in 2010-11. Eco-innovation has become a priority in the Government's innovation agenda (OECD, 2008), for example through the Clean Energy Initiative, the Green Car Innovation Fund, the Global Carbon Capture and Storage Institute, and others now managed by the *Australian Renewable Energy Agency* (ARENA).

2.5 KNOWLEDGE PRODUCTION

2.5.1 Quality and excellence of knowledge production

Investment in intangibles at 5.9% of GDP (2006) ranked Australia 14th among the 17 OECD countries.[20] In 2010, GERD was €24.7b (A$30.1b), an increase of 9% over 2008-2009. Over the ten years to 2010-2011, GERD has tripled in nominal figures. GERD/GDP increased from 2% in 2006-2007 to 2.2% in 2010-2011. As shown in the chart below, 58% of GERD is expenditure by business enterprises (BERD) and 27% is expenditure in the Higher Education sector (HERD). In terms of output indicators, Australia ranks 10th in the OECD in publication-intensity and share of world publications, but considerably lower (18th) in terms of publication citation rates. Australia's overall patenting performance is relatively low and is declining. In terms of triadic patent families per million population (12.6 in 2010) and patent applications under PCT per million population (77 in 2011) Australia ranks 19th and 20th in the OECD, respectively. The extent of new-to-the-world product innovations by Australian firms is near to the bottom of the range among OECD countries –

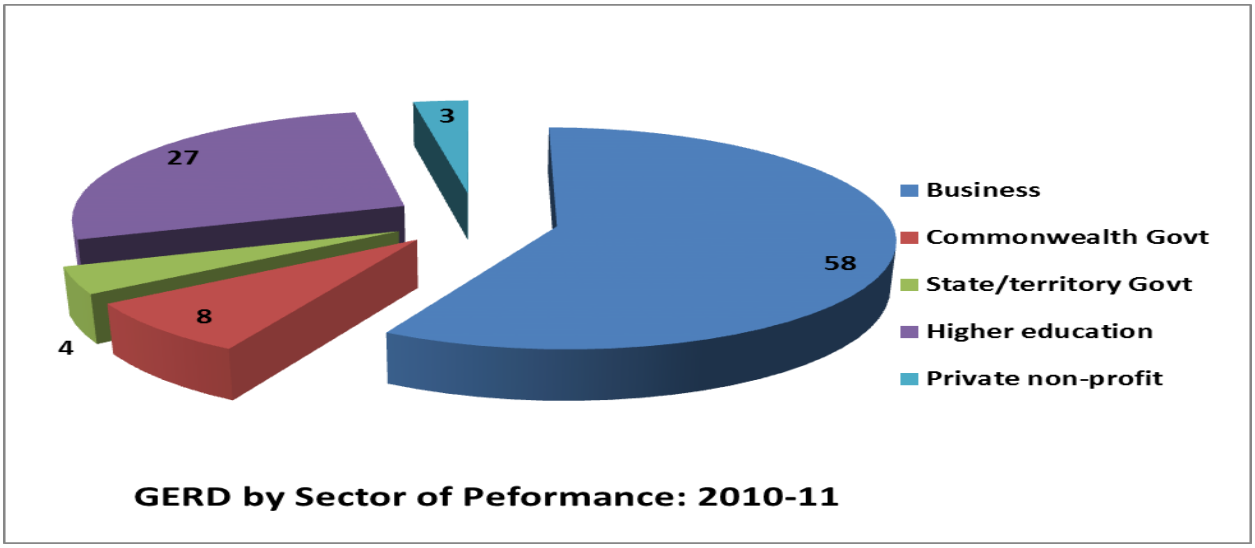
[18] DIISRTE (2011) Australian Innovation Systems Report, 2011; DIISRTE (2012) Australian Innovation Systems Report, 2012

[19] DIISRTE (2011) Australian Innovation Systems Report, 2011

[20] *OECD Science, Technology and Industry Scoreboard, 2011*

reflecting the relatively low level of manufactured exports by domestic firms (for details see ERAWATCH Research Inventory, Australia Country Fiche 2011[21]).

Figure 3: GERD by Sector of Performance



Source: DIISRTE (2013) Australian Key Innovation Indicators

2.5.2 Policy aiming at improving the quality and excellence of knowledge production

Raising the quality of research funded by the government is the first listed priority of the Government's Innovation Priorities.[22] While universities are autonomous in terms of governance and management, they have extensive and increasing reporting requirements. The current policy direction is to link all funding to universities to either competitive processes or performance assessments. The aim of the Sustainable Research Excellence (SRE) Programme is to shift a component of block grants to performance assessments based on the Excellence in Research for Australia (ERA) assessments – a comprehensive evaluation of research performance based on international benchmarking.[23] The performance of all research organisations and programmes is evaluated. Performance at an aggregate level is evaluated annually through the *Innovation Systems Report*, which uses a wide range of national and comparative international performance metrics and assesses performance in relation to the National Innovation Priorities. The PROs are monitored by their administering agency and evaluated periodically. The individual CRCs are monitored through a set of detailed metrics and evaluated a number of times over their (typically seven year) life. The overall Programme has been evaluated at least five times over its 20 year life.

[21] http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/; see also DIISRTE (2012) Australian Innovation Systems Report, 2012.
[22] http://www.innovation.gov.au/Science/ResearchInfrastructure/Pages/NCRIS.aspx
[23] Further information on the ERA is in Analytical Report, Australia - 2011

2.6 KNOWLEDGE CIRCULATION

2.6.1 Knowledge circulation between the universities, PROs and business sectors

A range of *indicators* suggests that the level of interaction between industry and research organisations in Australia is relatively low and not improving. For example, the proportion of large firms collaborating for innovation (24.4% in 2010) was the lowest in the OECD (See Annex Table A1).[24]

A variety of mechanisms encourages and supports collaboration, or brings research and industry together in councils and committees of various types. The most recent initiative (February 2013) is a €400m (A$500m) programme over five years to establish up to 10 *Industry Innovation Precincts*, linking industry and the research community around specific technology and enterprise development objectives. This programme will coordinate with the €192m (A$250m) *Industrial Transformation Research Programme* (2011) delivered through the ARC, which intends to support up to 20 'research hubs' involving research-industry collaboration in applied technology in addition to encouraging research and engineering students to engage with industry through training centres. In May 2012, a €23m (A$30m) *Manufacturing Technology Innovation Centre* for industrial product and process innovation was announced within the Enterprise Connect Programme.

2.7 OVERALL ASSESSMENT

Resource Mobilisation. With the generally benign economic context of the past decade GERD sustained high growth, as also did BERD until 2009-2010. The incoming government in 2008 increased investment in R&D, largely in HERD, and initiated a range of reviews. Following a review of the innovation system, an R&D tax credit scheme was introduced to replace the tax concession. In 2010, Commercialisation Australia was formed to support early stage ventures. It replaced a number of earlier funding and support schemes, and aims to more directly address the capabilities of new ventures. A National Enabling Technologies Strategy has been developed, and following an extensive *review* a research workforce strategy - *Research Skills for an Innovative Future* - was released in 2011.

Knowledge Demand. The growth of mineral exports is reshaping the economy and driving structural change. Australia has a relatively low export-intensity and a relatively large proportion of mining firms; low to medium-technology manufacturing firms (within a shrinking manufacturing sector); and small firms and foreign-owned firms. Mining and services firms increased their share of BERD and of exports. There is a 'mismatch' in the areas of focus of BERD and HERD. FDI into Australia is over €40b (A$50b) in 2012, with increasing investment from China and India, although the stock of FDI is dominated by US, European and Japanese firms.

Knowledge Production. BERD accounts for over 58% of GERD, and HERD for a further 27%. There has been a strong investment in research infrastructure with the development of a long-term strategy and the creation of multi billion Euro investment fund, financed by past budget surpluses. Australia ranks toward the middle of OECD countries in terms of most indicators of research inputs, but toward the lower quartile in many indicators of research outputs – reflecting an economy with a small 'high

[24] For further information on linkages see Analytical Report, Australia – 2011 and Australian Innovation Systems Report, 2012.

tech' sector and a great deal of innovation through technology adaptation and integration. Productivity, relatively high in the 1990s, has slipped over the past several years. A major emphasis of research policy is raising research quality in the university sector, and the indicators suggest that this is happening.

Knowledge Circulation. Increasing inter-firm and industry-research collaboration are increasingly important priorities, although little that has been done has been effective in boosting links significantly. The impacts of the substantial initiatives introduced in 2011-2013 remains to be seen, and in the context of the commercial uncertainties facing many individual firms, major changes in industry-research engagement are unlikely to develop rapidly. Industry structure, the nature of innovation in industry, and the incentive structure for researchers limit such collaboration.

3 NATIONAL POLICIES FOR R&D&I

3.1 LABOUR MARKET FOR RESEARCHERS

3.1.1 Stocks of researchers

The following table summarises key indicators on research-related human resources.

Table 4: Australia's Research-Related Skill Base

Indicator	Level	Year	OECD Rank
Tertiary education expenditure (% GDP)	1.6%	2009	11th
Public expenditure on tertiary education (%GDP)	1.1%	2009	20th
Proportion of population aged 25-64 attaining tertiary education	37.6%	2010	9th
Proportion of population aged 25-34 with tertiary education	44.4%	2010	8th
Number of students completing higher degree by research in Australia	7400	2010	
Science and Engineering university graduates as a % of total university graduates	20.4	2007	22nd
PhD graduation rate	1.85%	2009	9th
Share of professionals and technicians in total employment	36.1%	2010	9th
Researchers - % of total labour force	0.81%	2008	12th
R&D personnel -% of total employment	1.25%	2008	14th
Local availability of specialised research and training services	5.3	2011	14th

Sources: DIISRTE (2013) Australian Innovation Systems Report, 2012; World Economic Forum, The Global Competitiveness Report 2010-2011

The overall engagement of human resources in R&D has grown strongly over the 2000-2001 to 2009-2010, particularly in the business sector. In absolute numbers the Higher Education sector is the dominant employer of research personnel, with 45% of the human resources devoted to R&D in 2008-2009; the small role of the business sector relative to most OECD countries reflects the relatively low level of BERD (for further details see ERAWATCH Research Inventory, Australia Country Fiche 2011[25]). Shortfalls in the domestic supply of researchers (HDR graduates) have in the past been met by international HDR students who remain in Australia (about 25% of HDR completions are international students and about 40% take up permanent residency) and by HDR qualified migrants. It is expected that these flows will meet any future domestic supply gaps[26].

The Australian Government has developed a comprehensive research workforce strategy - *Research Skills for an Innovative Future* - released in 2011, which includes issues of researcher mobility. The strategy was developed in response to issues raised in a number of reviews (DIISRTE, 2010e) examining research training and the research workforce. It also addressed concerns regarding the career paths for research students and the adequacy of the research training system to prepare them

[25] http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/
[26] For detailed assessment see: http://www.innovation.gov.au/Research/ResearchWorkforceIssues/Documents/SupplyDemandandCharacteristicsoftheHDRPopulation.pdf

for varied career outcomes. The Strategy also responds to the report of the House of Representatives Committee on Industry, Science and Innovation inquiry into research training and research workforce issues - '*Building Australia's Research Capacity*'[27] (Commonwealth of Australia, House of Representatives, 2008). This review raised issues of internal and international mobility.[28]

3.1.2 Providing attractive employment and working conditions

The working conditions for researchers is an issue addressed in *Research Skills for an Innovative Future*, and the implementation of that strategy through the Research Workforce Strategic Advisory Group and the Research Training Quality Working Group. Concerns about the issue had been raised during consultations during the strategy development and in a study (Coates, 2009), which reported a relative decline in the attractiveness of Australian academic employment on a number of measures, including job satisfaction, workload and some aspects of research support. The high proportion of junior research staff on short-term contracts and the challenges of a research career continue to be major issues (see 3.1.4 below). DEST (2005) found that Australian universities are making extensive use of salary loadings and other incentives to attract new academic staff and retain existing staff. The main reason for the use of these incentives was because Australian academic salaries were relatively uncompetitive with comparable private sector salaries in Australia and some overseas academic salaries.[29] Women account for about one third of doctorate qualified people in Australia and continue to be under-represented at the senior levels of academia and public sector research organisations.[30] In 2008, less than 30 per cent of academic positions above the senior lecturer were occupied by women and only 23 per cent of research scientists in the CSIRO are women. Recent changes to the ARC Discovery Grants Projects scheme to increase opportunities for early career researchers along with two high level fellowships for senior women researchers aim to raise the success rates of women on competitive grants. The NHMRC's *Women in Science Working Committee* aims to gain a better understanding of the issues that face women researchers in health and medical research in terms of career progression and retention.

3.1.3 Open recruitment and portability of grants

Universities are autonomous and hence independent, within national law, in terms of recruitment, salaries and conditions. Subject to obtaining a temporary or permanent visa, which is increasingly straightforward for researchers, entry to research or academic positions is in practice open to non-nationals. Temporary residence visas are increasingly used for both short and long-term research appointments. Advertising and recruitment is by the employing organisation. Recognition of

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[27] http://www.innovation.gov.au/Research/Documents/ACDSpresentation19October2010.pdf

[28] For further information on the reviews that informed these policy developments see Analytical Report, Australia – 2011.

[29] Coates et al (2009) *The attractiveness of the Australian academic profession: A comparative analysis* provides a detailed empirical analysis of the salary and conditions for academic staff in Australia. Further information on research careers is in Analytical Report, Australia – 2011. Economic conditions in many European countries have reduced this disparity.

[30] The impacts of career breaks, particularly for women, is recognised in the Research Workforce Strategy and supporting studies: http://www.arc.gov.au/media/ft11_decra12/factsheet_rws.htm

qualifications can be problematic where professional practice (for example in medical, engineering, legal or accounting services) requires recognition by the relevant professional association. The Australian Researchers' Mobility Portal was developed to provide resources to researchers considering a move to or from Australia. Research grants are portable across universities within Australia, but not offshore. While research fellowships are increasingly open to international applicants, they must reside in Australia during the term of the fellowship.[31]

3.1.4 Enhancing the training, skills and experience of researchers

A number of measures have sought to increase the exposure of research students to the business context or to increase skills in the commercialisation of research. One of the stated goals the *Cooperative Research Centre* (CRC) Programme was to develop more researchers who had industry-relevant experience. The Australian Postgraduate Awards Industry (APAI) of the ARC *Linkage* Programme has a similar objective. The *Commercialisation Training Scheme (CTS)* (2007-2012) was introduced to provide training in commercialisation for postgraduate research students with the aim that new researchers would be equipped with the necessary skills to bring research innovations to market.

The overall issue of the quality of research training was addressed in an October 2011 discussion paper - *Defining Quality for Research Training in Australia* - and the responses to that paper informed the development of the research workforce strategy.

There is also an increasing recognition that the core generic skills of graduates are often limited in communication, planning and organising and teamwork and preparedness for collaborative and interdisciplinary research. These issues are also addressed in the *Research Skills for an Innovative Future*, and the implementation of that strategy through the *Research Training Quality Working Group*. The role of the Research Workforce Strategic Advisory Group (RWSAG), which provides advice on the implementation of priority areas, includes:

- the effectiveness of the Research Training Scheme;
- new models for research training that explicitly focus on the professional employment needs of graduates;
- a web-based communication platform to promote research career opportunities and support in Australia; and
- standards for research training – but not standardisation.

An issue addressed in the strategy is the position of early career researchers. The ARC has created a pool of dedicated funds within the major Discovery grant scheme for *early career researchers*, and DIISRTE is working with research organisations to develop a Best Practice guide for managing these researchers.

3.2 RESEARCH INFRASTRUCTURES

Funding for research infrastructure is provided through four channels:[32]

- *Research Infrastructure Block Grants (RIBG)*;
- *Super Science Initiative*;
- *Education Investment Fund (EIF)*; and
- *National Collaborative Research Infrastructure Strategy (NCRIS)*

[31] Further information on researcher mobility is in Analytical Report, Australia – 2011.
[32] For further details see Analytical Report, Australia- 2012.

The National Collaborative Research Infrastructure Strategy (NCRIS) was a €400m (A$500m), seven year strategy (2004 to 2011), providing support for major research infrastructure. In total 27 projects have been funded through NCRIS. Following extensive consultations based on a discussion paper and a draft strategy an updated infrastructure strategy - 2011 Strategic Roadmap for Australian Research Infrastructure - was released in late 2011. The Roadmap places a high priority on national cooperation in research infrastructure investments, and encourages initiatives to develop international cooperation in future research infrastructure projects. Australia has long had specific funding mechanisms to support access by Australian researchers to international facilities.

3.3 STRENGTHENING RESEARCH INSTITUTIONS

3.3.1 Quality of National Higher Education System

A recent report, Mapping Australian higher education, issued by an independent 'think tank', the Grattan Institute, provides a useful overview of the sector, its performance and the challenges it faces.

There are 37 public sector universities (Universities Australia), two private universities, and two Australian branches of overseas universities.

Although there is no formal difference in the missions of universities, the older research-intensive universities dominate research income and publications, and the newer universities are tending to focus on more applied research and vocation-oriented courses. Growing competition among universities has led to the emergence of a number of groupings to represent different interests. These include the Group of Eight (Go8 -the larger universities), Australian Technology Network of Universities (ATN), Innovative Research Universities Australia, and New Generation Universities.

In 2010 HERD was €6.6b (A$8.3b) - a 20% increase over 2008 (a sustained increase at over 20% per annum since 2000) - and the research workforce was 69,200 (PYE). HERD was 0.59% of GDP. In 2008-2009 5.9% of HERD was funded by the business sector – the 11th highest in the OECD. Medical and health sciences accounted for 29% of HERD in 2010 - almost triple the value of the next highest research field, Engineering.[33]

Higher education exports (overseas undergraduate and postgraduate students enrolling in universities) increased to €8.2b (A$10.25b) in 2009-2010, and overall education exports exceeded €12b (A$15b) (2012) making education the largest service export, ahead of tourism, and the fourth largest export industry, directly behind coal, gold and iron ore.[34] For the decade prior to 2008, education exports grew by an annual average of 15.7 %, compared to 10.8 % for total exports, but this growth stalled in 2009. In 2010, over 44% (and rising) of the 25-34 age group had tertiary qualifications and the PhD graduation rate in 2009 was 1.85% (26% non-nationals). The government is aiming to raise significantly the proportion of high school graduates who enter university and is supporting universities to introduce new measures to assist students from lower socio-economic groups. A majority of undergraduates are female and the proportion of undergraduates undertaking science and engineering degrees (20% in 2007) is one of the lowest in the OECD.

[33] ABS (2012) 8111.0 - Research and Experimental Development, Higher Education Organisations, Australia, 2010

[34] For a detailed analysis of education exports see: Analysis of Australia's Education exports.

Research Performance

There are five Australian universities in the Shanghai top 100 Higher Education index (2012): Melbourne University (57), Australian National University (64), University of Queensland (90) Sydney University (93) and University of Western Australia (96). Five universities were in the top 100 for the field of Life Science and Agriculture and three in the field of Clinical Medicine and Pharmacy – these were clearly considered the fields of highest relative performance. Excellence in Research for Australia (ERA) evaluates the quality of the research conducted at Australian universities by discipline. The second round of assessments was in 2012. The *ERA 2012 outcomes* enable evaluation of research performance over time and are shaping research funding decisions.

Publications per researcher (in all sectors) at 0.4 in 2009 placed Australia at the 7th place in the OECD. Citations per publication, 5.71 in 2010, ranked Australia as 18th in the OECD (Bradley, 2008 and DIISRTE, 2012). Patenting performance is largely in the lower half of OECD countries: 17th in terms of share of world triadic patent families (19th when standardised by population) and 12th in the share of patent applications under the PCT (18th in relation to population).[35] Further information on research performance is provided in Section 2.4.[36]

3.3.2 Academic autonomy[37]

Universities are autonomous in terms of governance and management (including recruitment) but have extensive and increasing reporting requirements, and also opportunities to be consulted over policy changes.

The Commonwealth Tertiary Education Commission, which provided a joint mechanism for government and university policy development and debate, was closed in 1987. Since that time there has been a strong trend to extend market relationships to universities and to establish more extensive monitoring and accountability. This is expressed also in the formation of the Australian Universities Quality Agency and the systematic assessment of research performance by the ARC – despite Commonwealth funding accounting for a declining share of universities funding. At the same time University Councils have become more active in governance, exerting greater authority in relation to Vice Chancellors. The National Governance Protocols for Higher Education were first introduced in 2003. At the request of the Parliamentary Joint Committee on Higher Education, Universities Australia developed a voluntary code of best practice governance to replace the existing National Government Protocols for Higher Education Providers. This code was approved and endorsed by the Ministerial Council for Tertiary Education and Employment in July 2011. The final document is the *Voluntary Code of Best Practice for the Governance of Australian Universities*.

Academic salaries are established through negotiation at the level of the individual university, although these take place in the context of collective bargaining by the academic unions and the universities. Salaries for researchers funded through research grants are specified by the funding bodies.
There has been a high level of freedom to set research agendas, but the SRE encourages universities to concentrate funding in areas that are or might achieve high

[35] See WIPO (2009) *World Intellectual Property Indicators*. World Intellectual Property Organization 2009 Edition
[36] See also Chief Scientist of Australia, *Health of Australian Science*
[37] Further discussion of university governance is in Analytical Report, Australia – 2011.

performance ranking through the ERA. Universities are not free, at this stage, to set fees for students – although some deregulation is being considered. The number of students that universities can enrol was controlled but is now deregulated.

3.3.3 Academic funding

The primary programme for government funding of education in universities is the Commonwealth Grant Scheme (CGS), which provides funding (€4.78b (A$6b) in 2012-2013) to higher education providers in relation to domestic student enrolments in bachelor courses. Various other funding mechanisms provide an additional €720m (A$900m). Direct Commonwealth government funding of university research comprises performance-based block grants (about 44% of Commonwealth Government funding for university research) and project-based competitive funding (about 56%). However, the estimated Commonwealth contribution to HERD includes an additional component based on the estimated proportion of academic time (and hence salary) devoted to research. This assumption-based estimate accounts for over a third of the Commonwealth contribution to HERD. Over the four years 2009-1010 to 2012-2013, €400m (A$500m) has been provided under the Sustainable Research Excellence in Universities (SRE) to support universities in meeting the indirect costs of their Australian Competitive Grant (ACG) research activities.

In addition, the government has negotiated longer-term the '*mission-based compacts'* with each university, and these include agreement on a research strategy. The 2011-2013 compacts provide a framework for universities, within the overall framework of Government policy, to pursue individual goals and strategies. An overview of the content of these compacts for each university is provided in a *summary report*, which provides information on research activity, universities' plans to build capacity, pathways for delivery of teaching and learning, access for different social groups, and initiatives for collaboration, both locally and internationally.

3.4 KNOWLEDGE TRANSFER

3.4.1 Intellectual Property (IP) Policies

All Australian PROs and universities have explicit and published IP policies. These set out the ownership of IP and often also the basis for revenue sharing. In most cases the IP from university staff is owned by the university, but that for students is owned by the student. Universities have strong incentives to publish and publishing performance is assessed in terms of the outcomes of competitive research funding at the project level and as a basis for the allocation of block grants at the university level. The incentive structure for researchers is complex and contradictory. Success in commercial activities will augment but not substitute for the need for publications in high-level peer-reviewed journals.

All PROs and universities have some form of Knowledge Transfer Office – often linked to the research management office – and these usually have a leading role in contact with business partners or licensees. According to the *National Survey of Research Commercialisation 2010-11*, which provides very detailed data and international comparisons, the total number of commercialisation staff has risen by 61% since 2000. The average number of commercialisation staff per university is 4.3 across all research organisations; less than the averages for the US, Canada and the UK. However, many university researchers maintain consulting activities outside the scope of these KTOs – although most universities require that such activity is reported. Most universities, and particularly smaller ones, have difficulties in

maintaining the range and depth of capability to manage commercialisation. The KTOs are funded from central university funds, but also retain a proportion of commercialisation income. There is a national association of KTOs – *KCA* –which provides training and shares experience and best practice.

3.4.2 Other policy measures aiming to promote public-private knowledge transfer

Spinoffs

Australian start-up companies formed per €80m (A$100m) research expenditure have gradually declined from a peak of 2.2 in 2001 to 0.3 in 2011. The levels of spin off activity tend to be lower than those in US and Canada and particularly Europe and the UK (DIISRTE, 2012a). Spin off activity from universities and PROs is supported through three major mechanisms: the funding and advisory services of *Commercialisation Australia*; the range of measures that support venture capital providers; and the commercialisation aspects of programmes such as the CRC Programme; and the recently announced Industry Innovation Precincts.

Inter-sectoral mobility

The great majority of the research workforce in Australia is in the university sector. While there is a substantial flow of young researchers into business there is very little mobility from the business sector into the university sector.

Promoting research institutions - SME interactions

The 2010-2011 Innovation in Australian Business survey (ABS, 2012) estimated that over 2010, 13.7% of 'innovation-active' SMEs collaborated for innovation with HEIs or PROs (DIISRTE, 2012b). In view of the high proportion of SMEs in the business sector, improving research, SME links has long been a priority. Measures introduced to assist linkages include:

- The *CRC Programme* emphasises the objective that centres will have or develop collaboration with SMEs.
- *Researchers in Business* (RiB), is a component of the *Enterprise Connect Programme* which covers half of the salary of a researcher from a PRO or HEI working in a firm for up to 12 months.
- The *Industry Innovation Precincts* are intended to also coordinate delivery of some government support services to SMEs including initiatives supported by the €40m (A$50m) *Industry Collaboration Fund*.

Collaboration with SMEs is an element of the 'compacts' negotiated between universities and the government funding bodies (see Section 3.3.3).

Involvement of private sectors in the governance bodies of HEIs and PROs

The level of involvement by the private sector in the governance of HEIs and PROs varies widely. It is common for a senior business person, active on corporate boards, to join the board of a research organisation or the council or Senate of a university (Swansson, et al., 2005). The Australian universities established the *University Governance Professional Development (UGPD) Programme* in 2004 in order to collaborate over the development of improved governance.

The development of an active role by universities in their region has been largely ad hoc. This is in part because until 1980s most universities were located near the centre

of a major city. Closer and more strategic engagement has begun to be a more important issue as expressed in the 'compacts' currently negotiated between universities and the government funding bodies (see Section 3.3.3) and in the Joint Research Engagement (JRE) funding which aims at building greater collaboration between universities and the business and non-government sectors. In addition, the *Collaborative Research Networks* (CRN) programme aims to encourage smaller less research-intensive and regional higher education institutions to develop their research capacity by teaming up with other institutions in areas of common interest.

3.5 ASSESSMENT

In relation to the development of Australian research organisations, six points should be made:

1. There has been strong government support for research; particularly since 2008 and in universities. The overall level of research funding in universities has continued to grow at rates near 20% per annum. The Australian economy did not experience a recession as a result of the GFC, and funding for research has continued to expand.
2. Australia has a relatively large PRO sector (CSIRO, DSTO, ANSTO, AIMS).
3. The quality of Australian research, based on publication and citation rates, is relatively high. The research workforce benefits from a net inflow of researchers, including international students who complete PhD studies in Australia and remain (almost 50% remain in Australia).
4. Most research funding and policy is now administered by one department, DIISRTE. This department has pursued a reasonably comprehensive and systematic approach to reviewing and addressing, usually with extensive consultation with stakeholders, performance issues, including research quality, mobility and equity.
5. A characteristic of innovation, and hence industrial research, is the relatively low proportion focused on new-to-the-world products. This has major implications for the nature of demand for knowledge and talent by industry.
6. The structure of the industrial sector has a major bearing on the scope for research-industry links. While the GFC has not led to significant reductions in government support for research in universities, BERD, business funding of university research and commercialisation through spin-offs, have all declined.

4 INTERNATIONAL R&D&I COOPERATION

4.1 MAIN FEATURES OF INTERNATIONAL COOPERATION POLICY

The importance of a globally engaged research for access to new knowledge, talent, infrastructure, and for joint efforts to address global challenges, is well recognised.

The overall approach to international cooperation in research is essentially threefold:

1. The Commonwealth government has developed a range of bilateral and multilateral collaboration agreements, which identify shared priorities and facilitate collaboration. These inter-governmental mechanisms are administered by DIISRTE. The National Health and Medical Research Council (NHMRC) has a *European Union Collaborative Research Grants programme* (€0.8m (A$1m) available under each call).
2. The major national research funding schemes have been progressively modified to better support international collaboration of various types.
3. Individual researchers, research organisations and professional organisations have developed collaborative relationships at the project, discipline or organisation level.

DIISRTE maintains four overseas representatives: Washington, Brussels, New Delhi and Beijing. It has bilateral collaboration agreements with many countries and regions and among the most active are: the United States, Europe, China, India, Japan and Korea. Two have allocated research funding:

- *Australia-China Science and Research Fund*
- *Australia-India Strategic Research Fund*

The fields in which collaboration is particularly strong are: biotechnology, agriculture, marine science, renewable energy, climate change, information and communications technology, space sciences and astronomy and materials science.

The internationalising of the major research programmes has reduced some of the structural barriers to international collaboration:

- Changes to the ARC's funding policies support more extensive international collaboration in all ARC schemes;
- CSIRO's Flagship Collaboration Fund supports international participation in large-scale multidisciplinary research partnerships; and
- Revised (2008) guidelines for the Cooperative Research Centres (CRC) Programme, encourages global engagement and co-investment with international organisations.

Hence the overall approach is one of improving the enabling support while leaving the development of collaboration to essentially grass roots initiatives. The international collaboration supported by the Australian Research Council in 2009 (the most recent data available) provides a snapshot of the disciplinary focus of academic collaboration. Three research fields dominated collaboration: Ecology and Evolution; Biochemistry and Cell Biology; and Mathematics. Other particularly active areas were Materials Engineering and Interdisciplinary Engineering.

4.2 NATIONAL PARTICIPATION IN INTERGOVERNMENTAL ORGANISATIONS AND SCHEMES

Australia actively *participates* in the science-related fora organised by the OECD, UNESCO and *Australia-Pacific Economic Cooperation* (APEC). Other specific international collaborations include those in the European Molecular Biology Laboratory (EMBL) and in the Giant Magellan Telescope (GMT) located in Chile.[38] The most recent major collaboration is in the *Square Kilometre Telescope* consortia.

4.3 COOPERATION WITH THE EU

4.3.1 Participation in EU Framework Programmes

There has been interest at the policy level in increasing the extent of collaboration, with EU research programmes and at the bilateral level. This interest is expressed in the 2008 *European Union – Australia Partnership Framework*[39] and in the joint support for Connecting Australian-European Science and Innovation Excellence (CAESIE); a new organisation to facilitate linkages.

COST

There have been 85 instances of Australian institutions participating in COST actions 2005 to 2010. COST has also invited and funded 120 Australian researchers to participate in COST Action meetings over this period (Australia–European Union JSTCC, 2010). In mid-2010, Australian researchers were involved in 44 COST actions across a diverse range of research areas and involving a large number of different Australian research organisations.[40] Financial assistance is available for Australian professional researchers who are official members of a COST Action to undertake Short Term Scientific Missions (STSM) of COST and/or attend a workshop/meeting of COST.

Framework Programme

The level of Australian participation in the Framework Programmes has grown strongly since FP4 in 1994-1998:

- FP4 1994–1998: 60 projects;
- FP5 1999–2002: 90 projects;
- FP6 2002–2006: 173 projects.

The level of participation in the 7th Programme for Research and Innovation (FP7) has continued this growth. By 18 December 2012, a total of 767 eligible proposals were submitted in response to 355 calls for proposals involving 833 participants from Australia. Apart from proposals under the People Programme/Marie Curie Actions (147 mainlisted applications) the areas of the largest numbers of proposals involving the highest levels of funding sought were in Health, ICT, Research Infrastructure and Environment. These four areas accounted for over half of the mainlisted applications, and over two thirds of the projected cost of proposals, involving Australian

[38] A broad overview of international research collaboration is in Australian Parliament, *House Standing Committee on Industry, Science and Innovation* (2010) *Inquiry into Australia's international research collaboration*

[39] http://www.foreignminister.gov.au/releases/2008/fa-s163_eu_aust_partnership.html

[40] For details see: *Participation by Institutions from non-COST countries in COST Actions - Australia*. COST 4103/1/10 Rev 1. See Analytical Report, Australia- 2011 for background.

participation in FP7. The overall success rate for applications from Australia was 27.6%.

The details of Australian participation are shown in Table 5 and Table 6 below, and the key characteristics of this participation are:

- Australian participation in FP7 is strong. There are currently over 135 Australian research organisations involved in 120 FP7 cooperation projects with a total EU funding of €972m (A$1215m).
- Australia ranks 9th among the third countries (non-EU or associated countries) participating in FP7 in terms of number of participants.
- Australian research organisations have a high degree of success (28%) in their applications to the programme, higher than most other third countries (23% on average).
- While most Australian participants are required to bring their own resources, Australian research organisations nevertheless receive almost €5.2m (A$6.5m) of EU funding. Australia is attracting more funding than most other third countries.

Australia's research collaboration with the EU focuses mainly on the areas of information and communication technologies, health, and food, agriculture and biotechnologies.

- There is some involvement in the environment, energy, transport and industrial technologies and nanotechnology themes.
- Cooperation also takes place in the research infrastructure, international cooperation and science in society areas.
- Many of the projects involving Australian research organisations focus on common societal challenges for the EU and Australia: 'Bridging research on Ageing and ICT Development', 'Genetic Factors for Osteoporosis, 'Drought tolerant yielding plants', 'Research into Impacts and Safety in CO2 Storage', 'Future of Reefs in a changing environment', etc.

The Australian research organisations that are most heavily involved are CSIRO, and the leading research universities: University of Melbourne, University of Sydney and Australian National University. The top collaborative links are with the UK, Germany, France, the Netherlands and Italy. Many projects with Australian participation also involve other high-income partner countries: the United States, Canada, Japan, Korea are the most frequent partners involved.

Australia scores well in attracting funding from the European Research Council (ERC). There are 16 Australian Principal Investigators who have received prestigious ERC grants to work at European institutions (11% of all grants that went to third countries). Australia is also active in the EU mobility schemes. There are 48 Australian Marie Curie Fellows hosted by European institutions and 34 European Marie Curie Fellows based in Australia. Australian research organisations are involved in 46 Marie Curie International Research Staff Exchange Schemes (IRSES).

Table 5: Australia Contract type of the FP7 projects with country's participation

	Total	Mainlisted
Proposal Sub Funding Description	**Number of Proposals**	**Number of Proposals**
Collaborative project for specific cooperation actions dedicated to international cooperation partner countries (SICA)	14	5
Collaborative project (generic)	45	18
Collaborative Project targeted to a special group (such as SMEs)	19	4
Coordinating action	26	11
ERC Advanced Grant	18	2
ERC Starting Grant	18	1
Integrating Activities / e-Infrastructures	13	7
Marie Curie International Incoming Fellowships (IIF)	9	2
Marie Curie International Outgoing Fellowships (IOF)	356	59
Marie Curie International Research Staff Exchange Scheme (IRSES)	111	68
Large-scale integrating project	102	30
Network of Excellence	5	3
Research for SME associations/groupings	2	1
Research for SMEs	4	1
Small or medium-scale focused research project	131	30
Small or medium-scale focused research project INFSO (STREP)	96	16
Supporting action	33	15
	31	
Sum:	**1,033**	**273**

Table 6: Australian Participations in FP7

		All submitted		Mainlisted			
Proposal SP Description2	Proposal Program	No of Prop'ls	No of Applic's	No of Prop'ls	No of Applic's	Proposal Total Cost	Success Rate*
Not_Available	N/A	3	3				
Research Fund for Coal and Steel	RFCS	2	2				
SP1-Cooperation	ENERGY	23	26	9	11	44,823,222	42.31%
SP1-Cooperation	ENV	36	41	12	14	108,587,581	34.15%
SP1-Cooperation	HEALTH	81	95	21	26	186,416,221	27.37%
SP1-Cooperation	ICT	143	156	34	39	179,892,415	25.00%
SP1-Cooperation	KBBE	61	69	22	23	122,015,085	33.33%
SP1-Cooperation	NMP	22	25	6	6	57,208,963	24.00%
SP1-Cooperation	SEC	11	12	2	2	8,536,136	16.67%
SP1-Cooperation	SPA	5	5	2	2	6,433,917	40.00%
SP1-Cooperation	SSH	35	37	1	1	10,085,231	2.70%
SP1-Cooperation	TPT	22	28	6	8	41,565,983	28.57%
SP2-Ideas	ERC	38	43	3	3	5,639,791	6.98%
SP3-People	PEOPLE	497	531	129	147		27.68%
SP4-Capacities	INCO	9	13	6	10	9,161,702	76.92%
SP4-Capacities	INFRA	24	25	11	12	130,555,402	48.00%
SP4-Capacities	SiS	12	12	5	5	5,289,158	41.67%
SP4-Capacities	SME	7	8	2	2	3,082,997	25.00%
SP5-Euratom	Fission	2	2	2	2	53,412,458	100.00%
	Sum:	**1,033**	**1,133**	**273**	**313**	**972,706,262**	**27.63%**

applicants in mainlisted proposal / applicants in all submitted proposals - applicants

4.3.2 Bi- and multilateral agreements with EU countries

Europe is Australia's major research partner and a number of bilateral and multilateral *agreements* facilitate collaboration. The Joint Science and Technology Consultative Committee (JSTCC), established under the Agreement, meets regularly to exchange information and to discuss ways to enhance research collaboration. The 12th JSTCC meeting was in Brussels in October 2012. Australia and the European Union have *agreed* on a *Science and Technology Cooperation Roadmap for 2010-2012.*, and this is currently being updated. The *Australia-Europe Research Collaboration Fund (Europe Fund)*[41] is the key vehicle for the Australian Government research links with the European Union, and with European countries. Researcher mobility is supported via Australian participation in the European Commission's Marie Curie International Research Staff Exchange Scheme (IRSES). Under this scheme the *Australian Academy of Science* provides a contribution towards the costs for Australian research organisations to establish or reinforce long-term research co-operation through short-term institutional staff exchanges.

Most collaboration is with the United Kingdom, Germany and France. Based on the number of joint publications with Australian researchers, the major research partners in order are: the US, UK, China and Germany. DIISRTE supports S&T collaboration with a number of countries in Europe including: Germany, France and the United Kingdom. The major areas of collaboration vary across the individual European countries and include: molecular and medical sciences, water and solar energy technologies, astronomy and astrophysics, biodiversity, and nanotechnology. Medical and Health Sciences are by a large margin the largest area of research in Australian universities. The National Health and Medical Research Council (NHMRC) has a dedicated fund- *European Union Collaborative Research Grants program* – to facilitate collaboration with Europe.[42]

4.4 COOPERATION WITH NON EU COUNTRIES OR REGIONS

4.4.1 Main Countries

Collaboration with other countries: For collaboration with many Asian countries a government-to-government framework is often essential for counterparts to gain support and 'kick start' collaboration where there is a limited history of links.

- Collaboration with **China:** Collaboration with China[43] is important for Australia for a number of reasons: the rapid growth and quality of Chinese research, the significant number of Chinese researchers in Australia and the range of shared interests in, for example, energy technology. In 2011 a new Australia-China Science and Research Fund (ACSRF) was established to operate to 2013-4. Each government has committed €7m (A$8.8m) to the fund. A recent report, *Science and Research Collaboration between Australia and China*, provides a detailed analysis of the growing links between Australia and China.

[41] https://grants.innovation.gov.au/IAP/Pages/Doc.aspx?name=AustraliaEuropeFund.htm
[42] Further information on Australia's international research policy, strategy and performance is in Analytical Report, Australia-2001
[43] http://www.innovation.gov.au/Science/InternationalCollaboration/Pages/CollaborationwithChina.aspx

- Collaboration with **India:** The *Australia-India Strategic Research Fund (AISRF)* established in 2006 provides a framework of collaboration. It is Australia's largest fund dedicated to bilateral research with any country. There are four components to the AISRF: *Indo-; Australian S&T Fund*; *Indo-Australian Biotechnology Fund*; *Grand Challenge Fund*; and *Australia-India Fellowship Fund*. A wide range of research areas are supported through the fund, but the priority areas are: biotechnology; medicine and health; energy; food security, water and agriculture; marine and terrestrial environment.
- Collaboration with the **United States of America** (US): S&T collaboration with the US constitutes about 14% of all international collaborations in Australia. The Australia-US S&T Treaty, which came into force in 2007, facilitates collaboration. However, a diverse range of researcher links are very strong in universities and Government research agencies.
- Australia has long collaborated in research with *Japan*, with a treaty established in 1980. The main areas of collaboration are: marine science, biomedical sciences, chemistry, and astronomy.
- A series of bilateral science and research activities have been held with *Korea* including in the light alloys, fresh water resources, and fusion.
- Australia has a particularly close relationship with *New Zealand* and New Zealand is a member of Australia's Commonwealth, States & Territory Advisory Council on Innovation (CSTACI). The CSTACI is the high level advisory council on innovation to enhance coordination of innovation and science policy across Australia and with New Zealand. Most areas of collaboration are in areas of mutual strength: marine & freshwater biology, ecology and environment, molecular biology, medicine, geoscience and oceanography, pharmacology and plant & animal science.
- *Singapore* is Australia's main South-East Asian partner in science and research, with the most frequent collaboration in biotechnology, energy, engineering and information sciences.

4.4.2 Main instruments

The organisation with the central responsibility for promoting and facilitating international research collaboration is DIISRTE. It pursues this role through essentially three mechanisms:

- Negotiating bilateral and multilateral agreements and developing collaboration under these agreements through joint priority-setting inter-governmental committee meetings and the organisation of workshops involving researchers.
- The development of national research funding schemes to ensure that these support international collaboration and the establishment of some dedicated funds for some countries. However, as noted in Section 4.1, the approach to international research collaboration has evolved to a position where the main research funding schemes and research organisations are the primary mechanism of funding, rather than dedicated collaboration funds.
- A network of S&T Counsellors in four countries (See Section 4.1)

4.5 OPENING UP OF NATIONAL R&D PROGRAMMES

Australia research funding schemes are changing in response to the increasing globalisation of research. Most funding programmes (such as *those of the ARC*) have been modified to facilitate international collaboration, which is an explicit policy objective. International research engagement is seen as vital for maintaining the quality of research, enabling access to new and/or complementary knowledge and facilities, and reducing costs.[44] The significant research human resource initiatives are:

- The Future Fellowships scheme was established in early 2008. Over a five-year period (2009–2013) the scheme is offering four-year fellowships to 1,000 international or Australian mid-career researchers. The Australian Laureate Fellowships scheme administered by the ARC and the *Australia Fellowships* scheme administered by the NHMRC aim to attract more senior international and Australian researchers. In the *Australian Laureate Fellowships* scheme, fellows are eligible for project funding in addition to a salary supplement while under the *Australia Fellowships* scheme a one-line budget of €580k (A$725k) per year is provided.
- The *Endeavour Research Fellowships*, administered by DIISRTE, provide financial support for postdoctoral fellowships to undertake short-term research, in any field of study in Australia. Fellowships awarded through the ARC *Discovery Projects* scheme are now open to international researchers. In the 2012 round, a total of 809 Endeavour Awards were offered. Of these 678 Awards were offered to international students, researchers and professionals and 131 Awards were offered to Australians for study, research or professional development abroad.
- Through the *International Postgraduate Research Scholarships* (IPRS), the Commonwealth Government provides about €14.5m (A$18.1m) to attract international postgraduate students to areas of research strength in Australian universities. The objectives are to attract talented researchers and to support these areas of research. Scholarships are open to international students. Following a review the Government is now providing access to Australian Postgraduate Awards by recipients of International Postgraduate Research Scholarship (IPRS) awards from 2011, on a competitive basis.[45]
- As discussed in Section 4.1, recent changes in some funding programmes have also significantly increased the scope for international collaboration with all countries. For example, among the 925 ARC Discovery Projects announced in October 2009, 104 received one or more International Collaboration Awards.[46].

For ARC Linkage Projects, rules for funding commencing in 2009 relaxed the citizenship and residency requirements for Australian Postgraduate Award (Industry) (APAI) students. All ARC fellowships are open to non-Australian citizens.

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[44] For an exposition of the ARC strategy see:
http://www.arc.gov.au/general/international_strategy.htm

[45] Australian Government (2010), *International Postgraduate Research Scholarships Evaluation*, Canberra 2010

[46]
http://www.innovation.gov.au/Research/Documents/ACDSpresentation19October2010.pdf

4.6 RESEARCHER MOBILITY

4.6.1 Mobility schemes for researchers from abroad[47]

Information for researchers moving to Australia is facilitated by the *Australian Researchers Mobility Portal*, which is now linked to the European Researcher Portal, *EURAXESS*.

The Future Fellowships scheme and particularly the Australian Laureate Fellowships scheme aim to attract Australian researchers (as well as non-Australian researchers) to/back to Australia.

4.6.2 Mobility schemes for national researchers

As noted in Sections 4.1 and 4.5 all national research funding schemes have been modified to provide greater support for researchers to collaborate internationally. The *Australian Researchers Mobility Portal* provides information on support for Australian researchers to work overseas. The importance of researcher mobility is addressed in the research workforce strategy, *Research Skills for an Innovative Future*, but no new initiatives have been announced.

[47]Further background information is in Analytical Report, Australia – 2011.

5 CONCLUSIONS

The incoming government in 2007 significantly raised public investment in research, particularly in universities, building on some substantial increases in research funding by the previous government. Australia has not experienced a recession due to the global financial crisis, and although the growth in government funding is more restrained, HERD and GOVERD have continued to increase and new research initiatives have been introduced.

The Innovation, Industry, Science and Research portfolio, with the Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE) as its administrative and policy development core, accounts for the majority of research and innovation policy and funding. Following a review of the national innovation system in 2008 and subsequent new innovation policy framework in 2009, innovation and research policy has continued to develop through a range of consultative mechanisms and reviews of programmes and issues. The most recent major policy initiative (February 2013) was the industry and innovation statement, *A Plan for Australian Jobs*, which included €400m (A$1b) over five years to establish up to 10 Industry Innovation Precincts. As recommended in the 2008 review, a set of national innovation priorities have been established, setting out goals and benchmarks for research quality, linkages, innovation activity and international collaboration, and other dimensions of innovation system performance. Performance in relation to these priorities, and their goals and benchmarks, is reported annually in the comprehensive Australian Innovation System Report.

The research system is pluralist and largely based or investigator-led research within a broad set of national research priorities. There has been a reluctance to develop strong strategies or mechanisms to support priority technologies or capabilities. There are a number of advisory and quasi-coordinating bodies at the national, inter-agency and sectoral levels. The dominant approach to international research collaboration is also bottom-up, although there is some prioritising, in the case of some bilateral programmes with dedicated funding (e.g. China and India).

With some minor exceptions, sectoral policy is not a strong driver of research allocations. Technology priorities have also generally not been major drivers of research allocation, although some priority has been attached to enabling technologies, such as ICTs and biotechnology, and an enabling technologies strategy is under development. Clean energy technologies were a major focus of funding initiatives since 2008. A recent review of public sector research concluded that “a national strategic dialogue and better coordination of research effort and investment are critical to Australia given its need for scale and world-class capability in areas of research of national importance.”

The long-standing R&D tax concession has not been a key driver of industry investment in R&D, but, along with overall innovation policy, contributes to industry awareness. A revised scheme, based on a tax credit has been introduced and aims to more effectively assist smaller and fast growth firms. BERD grew strongly for the decade up to the 2008, declined slightly in 2009-2010, and resumed growth in 2010-2011.

The characteristics and challenges of the Australian research system need to be understood within the context of the structure of the economy. Several characteristics

are vital: the manufacturing sector is relatively small and even within that sector most industries are low to medium technology level (in particular there are very few large research intensive firms); the services and resources sectors are relatively large; and there is a relatively high role by SMEs. Partly as a consequence, Australia has a significantly lower proportion of researchers in the business sector (less than 30 per cent of all researcher person years of effort in 2008-2009) and a correspondingly large role in research by public research organisations. These characteristics are expressed in the pattern of innovation and research performance. Patenting and the allocation of innovation effort to new to the world product innovations are toward the bottom of the OECD table. Much innovation in industry is focused on the modification and adaptation of technology developed in other countries. Conversely, academic/science performance, as indicated by publications, citations and international collaboration is toward the upper end of the range among OECD countries. Linkages between the research sector and industry are on the whole poor – with some exceptions. The evolution of the research and innovation system has led to quite strong research–industry links in the resource and agricultural sectors, but less so in many manufacturing and services industries. Several schemes support research–industry collaboration but have had only a modest impact.

If a resource industry cluster could be demarcated, including the mining, engineering, oil and gas industries and the manufacturing and service firms that supply them, this cluster would be the dominant industrial research grouping in Australia.

The major fields of research in universities are medicine and other life sciences, while the dominant fields in industry are engineering and ICT. Graduates in SET account for only about 20% of bachelor degree graduates. The recent growth in the resources industry and in the development of related infrastructure has led to significant skill shortages in engineering and mining-related disciplines.

The indicators of research-industry links and the direct commercialisation of public sector research, suggest a mixed performance. The proportion of HERD and GOVERD funded by business is in the top half of the OECD range, but indicators of the frequency of collaboration in the business sector are toward the bottom of the OECD range. Indicators of the commercialisation of public sector research through licencing and spin offs suggest a generally comparable but declining performance, slipping below the rates of comparator countries.

In the context of long-term under-funding of universities, recent increases in research funding have focused on the higher education sector and have included greater support for competitive grants and fellowships and for infrastructure. Funding for HERD is about evenly allocated to competitive schemes and performance-based block funding.

A series of significant initiatives have strengthened the research system and put in place a more systematic foundation for policy and the allocation of funding. These initiatives include: the evaluation of university research performance through the Excellence in Research for Australia (ERA) initiative linked to the Sustainable Research Excellence (SRE) aiming to drive investment into high performing research groups; the Strategic Roadmap for Research Infrastructure investment linked to substantial increases in funding for infrastructure; and the comprehensive research workforce strategy. The inflow of researchers from overseas is a vitally important mechanism for strengthening, if not retaining, the research workforce. The government's ambitious objectives for increasing the level of research will require a sustained growth in the research workforce that cannot be met by the current level of

domestic supply. The inflow from overseas is largely through two channels: researchers recruited by research organisations and universities; and overseas students who remain in Australia after completing a PhD at an Australian university (currently more than 25% of such graduates remain in Australia). Overall about 50% of the stock of PhD qualified people in Australia were born overseas.

International research collaboration is an important component of research policy. Recent initiatives have increased support for collaboration and opened domestic research funding programmes to greater participation by non-nationals. However, there is little overall strategy to guide the development of international research collaboration, despite low levels of industry – research interaction. While research collaboration with the traditional partners in Europe and North America continues to expand, collaboration with India and particularly China is growing more rapidly.

Several recent research and industry capability initiatives have been in the area of environmental technologies, for example, the substantial increase in funding for the Clean Energy Initiatives and the earlier support for the Global Carbon Capture and Storage Institute. The introduction of a Carbon Tax in July 2012 may increase the availability of funds for further research into 'carbon-reduction' technologies.

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7 LIST OF ABBREVIATIONS

AIMS	Australian Institute of Marine Science
ANSTO	Australian Nuclear Science and Technology Organisation
ANU	Australian National University
ARC	Australian Research Council
ARCom	Australian Research Committee
BERD	Business Expenditures for Research and Development
CAGR	Compound Annual Growth Rate
CCI	Coordination Committee on Innovation
CERN	European Organisation for Nuclear Research
COST	European Cooperation in Science and Technology
CRC	Cooperative Research Centres
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSTACI	Commonwealth, States and Territories Advisory Council on Innovation
DIISRTE	Department of Industry, Innovation, Science, Research and Tertiary Education
DSTO	Defence Science and Technology Organisation
ERA	Excellence in Research Australia
ERA-NET	European Research Area Network
ERDF	European Regional Development Fund
ERP Fund	European Recovery Programme Fund
ESA	European Space Agency
ESF	European Social Funds
ESFRI	European Strategy Forum on Research Infrastructures
EU	European Union
EU-27	European Union including 27 Member States
FDI	Foreign Direct Investments
FP	European Framework Programme for Research and Technology Development
FP7	7th Framework Programme
GA	GeoScience Australia
GBAORD	Government Budget Appropriations or Outlays on R&D
GDP	Gross Domestic Product
GERD	Gross Domestic Expenditure on R&D
GOVERD	Government Intramural Expenditure on R&D
GUF	General University Funds
HEI	Higher education institutions
HERD	Higher Education Expenditure on R&D
HES	Higher education sector
IP	Intellectual Property
NCRIS	National Collaborative Research Infrastructure Strategy
NHMRC	the National Health and Medical Research Council
NICTA	National ICT Centre of Excellence
NRIC	National Research Infrastructure Council

OECD	Organisation for Economic Co-operation and Development
PMSEIC	The Prime Ministers Science Engineering and Innovation Council
PRO	Public Research Organisations
R&D	Research and development
RI	Research Infrastructures
RIRDCs	Rural Industry R&D Corporations
RTDI	Research Technological Development and Innovation
S&T	Science and technology
SF	Structural Funds
SME	Small and Medium Sized Enterprise
UA	Universities Australia
VC	Venture Capital

8 ANNEX 1: ADDITIONAL TABLES

Annex Table A1. Australia's relative performance in knowledge exchange

Indicator	Performance	Year	OECD Rank
Innovation-active firms collaborating with universities or PROs	9.6%	2010	
Innovation-active SMEs collaborating in innovation with universities or PROs	9.6%	2010	
Innovation-active large firms collaborating in innovation with universities or PROs	13.7%	2010	
Innovation-active large firms collaborating in innovation with PROs	5.8%	2004-6	22nd
Australian-authored papers co-authored by researchers >1 Australian research institution	31%	2001-5	
Gross income from Licences, Options and Assignments by publicly-funded research organisations & universities	€229m (A$286m)	2009	
Gross income from contracted research by publicly funded research organisations and universities	€0.96b (A$1.2b)	2009	
Number of Start-up companies in which PROs or universities have an equity holding	176	2009	
Share of patents owned by universities & government	7.0%	2003-5	8th
HERD financed by business	4.1%	2010	12th
GOVERD financed by business	9.9%	2008	7th

Source: DIISRTE (2012), Australian Innovation Systems Report, 2012; ABS (2010) Innovation in Australian Business 2008–09 cat. no.8158.