ERAWATCH COUNTRY REPORTS 2010: Australia

ERAWATCH Network

Don Scott-Kemmis
Pacific Innovation

Acknowledgements and further information:

This analytical country report is one of a series of annual ERAWATCH reports which cover the EU Member States, Countries Associated to the EU Seventh Research Framework Programme (FP7) and, since 2011, selected third countries (ERAWATCH International).

ERAWATCH is a joint initiative of the European Commission's Directorate General for Research and Innovation and Joint Research Centre - Institute for Prospective Technological Studies (JRC-IPTS). The reports are produced, under contract, by the ERAWATCH Network.

The analytical framework and the structure of the reports have been developed by the Institute for Prospective Technological Studies of the Joint Research Centre (JRC-IPTS) with contributions from Directorate General for Research and Innovation and the ERAWATCH Network.

The report is only published in electronic format and is available on the ERAWATCH website (http://erawatch.jrc.ec.europa.eu/). Comments on this report are welcome and should be addressed to jrc-ipts-erawatch-helpdesk@ec.europa.eu.

Executive Summary

Australia is large almost twice the size of Europe (EU27) but with 22.5 million people, less than 5% of the 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 2010. GDP per capita was about €29,000 in 2010.

Australia is experiencing a resources boom. Almost 50% 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 ore made up around 50% of Australia's exports in 2009. Other key exports are education services, tourism, motor vehicles and beef. The EU accounts for about 15% of Australia's two-way trade.

R&D intensity was 2.2% in 2008-9, higher than the 2009 EU27 level of 1.91%. GERD/GDP has steadily increased from 1.47% in 2000-1. BERD accounts for about 60% of GERD, a proportion that has grown from 0.70% of GDP in 2000-1 to 1.35% in 2008-9. Majority foreign owned firms accounted for almost a third of BERD in 2008-9.

The research system is pluralist, largely based or investigator-led research within a broad set of national research priorities. Sectoral policy and technology priorities have 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. The Innovation, Industry, Science and Research portfolio 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 long-standing R&D tax concession has not been a key driver of industry investment in R&D, but along with overall innovation policy, it contributes to industry awareness. A revised scheme, based on a tax credit, is planned and aims to more effectively promote smaller and fast growth firms. The future trend in BERD is uncertain due to a combination of factors - structural change due to growth of resource exports and the rising exchange rate, competition for human resources, and the challenge of growing services exports into emerging markets.

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 new research performance assessment framework will focus funding on high performing research teams.

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. 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.

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. Strategic Roadmap for Research Infrastructure investment Proposed shift from an R&D tax deduction to an R&D tax credit aims to better support small high growth firms and to also encourage overseas investment into R&D. Research programmes been 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.	+ Increase in funding for research and infrastructure. + Extensive consultative mechanisms across states, ministries and departments. + More strategic approaches to assessment, priorities and human resource development. + Research workforce strategy is under development. + 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. - Delays or restrictions on visas.
Innovation policy	Introduction of the National Enabling Technologies Strategy, including the development of foresighting. The formation of Commercialisation Australia, 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 in the context of strategies to support pilot plants and research.	+ Development of consultative councils and boards in many sectors. + Initiatives to strengthen capability in 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.	+ Substantial increase in funding into the Education Investment Fund (now over €8b) will support investment in research and teaching infrastructure. - 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, fellowships and research project funding has been widened.	+ Science and society awareness programmes and initiatives - 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.

European Research Area

Assessment of the national policies/measures which correspond to ERA objectives[1]

	ERA objectives	Main policy changes	Assessment of strengths and weaknesses
1	Ensure an adequate supply of human resources for research and an open, attractive and competitive labour market for male and female researchers	An extensive review of research workforce supply and demand has been completed. A research workforce strategy released in 2011. 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 study not strongly attractive to Australian nationals
2	Increase public support for research	Substantial (25%) increase in government funding of research from 2008-9.	+ Strong government budget - Lack of strategic focus
3	Increase coordination and integration of research funding	Coordination mechanisms at the federal inter-governmental (inter-ministerial and inter-departmental levels. Explicit but broad national research priorities.	+ Primary reliance on bottom-up investigator led research - lack of coherent strategic framework
4	Enhance research capacity	Systematic approach to research workforce development; Strong investment in research infrastructure; Some targeted investment in IT, biotech and other 'enabling technologies'.	- Little focus on developing research capability in industry
5	Develop world-class research infrastructures (including e-infrastructures) and ensure access to them	Development of an infrastructure development roadmap; Development of substantial funds for infrastructure; Approach to funding emphasises openness; Additional new infrastructure funding programme emphasises relevance to industry.	+ Sustained funding; + Emphasis on shared facilities.

[1] Of course non-ERA countries do not strive to achieve ERA objectives. This part of the report is simply to allow a comparison with the activities of ERA countries on these issues

	ERA objectives	Main policy changes	Assessment of strengths and weaknesses
6	Strengthen research institutions, including notably universities	Systematic research evaluation (ERA); Linking research performance to core funding (SRI)'; Negotiation of performance 'compacts' with universities.	+ Increased funding for research and infrastructure + Clear performance criteria - Base funding of university' teaching inadequate - Few incentives for collaboration with industry.
7	Improve framework conditions for private investment in R&D	Long standing R&D tax concession; Proposed new tax credit scheme; Wider eligibility for multinational company research to subsidies	+ entitlement scheme gives clarity + Greater incentive for new ventures (tax credit scheme) - Level of incentive has declined with declining corporate tax rates - Uncertainty as future policy remains unclear
8	Promote public-private cooperation and knowledge transfer	Mechanisms include the Cooperative Research Centres Programme (CRC); ARC Linkage Programme and the Rural Research and Development Corporations (RDCs) and the CSIRO Flagship Programme	+ Stable programmes - Lack of a flexible bilateral collaborative applied research mechanism - Lack of a strategic orientation to industry collaboration.
9	Enhance knowledge circulation	Opening of university research funding to non-nationals. Development of international research links	+ Review of international links programme + Increasing researcher mobility + Extensive formal and informal international collaboration. + Substantial role of foreign-owned firms - Remote location
10	Strengthen international cooperation in science and technology	Increasing range of international research collaboration arrangements (e.g. with China and India); Increase in funding within these arrangements; Increase in strategic orientation in collaboration mechanisms.	- Little assessment of the evolution and outcomes of collaboration - Limited industry participation in collaboration
11	Jointly design and coordinate policies across policy levels and policy areas, notably within the knowledge triangle.	Well developed consultative and coordination mechanisms and approaches	- Lack of systematic collaboration development mechanisms
12	Develop and sustain excellence and overall quality of research	Systematic research quality evaluation (ERA)	+ Sustained funding for research in the context of increased evaluation.
13	Promote structural change and specialisation towards a knowledge-intensive economy	Initiative to develop a national enabling technologies strategy	+ Increasing focus on education and skills in all areas
14	Mobilise research to address major societal challenges and contribute to sustainable development	Strong increase in funding for 'Clean Tech'; Greater funding for environmental research.	- Poor linkages between research and market formation and commercialisation.

	ERA objectives	Main policy changes	Assessment of strengths and weaknesses
15	Build mutual trust between science and society and strengthen scientific evidence for policy making	New Science Awareness Strategy	+ Good capacities and open channels for evidence to contribute to policy

TABLE OF CONTENTS

1 Introduction

The main objective of the ERAWATCH International Analytical Country Reports 2010 is to characterise and assess the evolution of the national policy mixes for the non-EU countries in the perspective of the Lisbon goals and of the 2020 post-Lisbon Strategy, even though they do not pursue these policies themselves. The assessment will focus on the national R&D investments targets, the efficiency and effectiveness of national policies and investments into R&D, the articulation between research, education and innovation. In doing this, the 15 objectives of the ERA 2020 are articulated.

Given the latest developments, the 2010 Country Report has a stronger focus on the link between research and innovation, reflecting the increased focus of innovation in the policy agenda. The report is not aimed to cover innovation per se, but rather the 'interlinkage' between research and innovation, in terms of their wider governance and policy mix.

2 Performance of the national research and innovation system and assessment of recent policy changes

The aim of this chapter is to assess the performance of the national research system, the 'interlinkages' between research and innovation systems, in terms of their wider governance and policy as well as the most recent changes that have occurred in national policy mixes in the perspective of the Lisbon goals. Each section identifies the main societal challenges addressed by the national research and innovation system and assesses the policy measures that address these challenges. The relevant objectives derived from ERA 2020 Vision are articulated in the assessment for comparison reasons.

2.1 *Structure of the national research and innovation system and its governance*

This section gives the main characteristics of the structure of the national research and innovation systems, in terms of their wider governance.

Australia, the 6th largest country, covers 7.7m square kilometres - 50% greater than Europe. The population in 2010 was 22.5 million. GDP in 2009-10 was €937b and grew at 2.3% from the previous year. Australia did not experience a recession due to the financial crisis. Minerals and petroleum account for the majority of exports.

In 2008-9, GERD was €20.2b, 2.2% of GDP, having grown strongly for several years. BERD has grown from 0.62% of GDP in 1999-2000 to 1.34% in 2008-9. By 2009-10 about 24% of GERD was performed in the Higher Education sector, 12% in PROs. Australia accounts for about 3.2% of world research publications (Thomson Reuters, 2010). Australian research is internationally linked - in 2003 almost 40% of science and engineering publications were co-authored with foreigners, and the proportion of international co-authorship has grown strongly since 2000. Over 2004-8, papers co-authored with Europeans accounted for almost 50% of all internationally co-authored papers with an Australian author. Over 2000-10, collaboration with China, Singapore and India grew strongly, displacing Germany, Denmark and Belgium from the list of the top-ten collaborating countries. Affiliates of foreign firms accounted for almost 40% of BERD in 2006.

Main actors and institutions in the research and innovation system

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 CSIRO 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, conduct enquires, and by the Prime Minister’s Science, Engineering and Innovation Council

(PMSEIC), which can be influential in some policy issues, but has not had a dominant role. At the operational level research policy coordination is supported by:

- The Commonwealth States and Territories Advisory Council on Innovation (**CSTACI)** provides coordination between Commonwealth and State governments;
- The Coordination Committee on Innovation (CCI) includes representatives of all government departments and agencies that fund or perform research and facilitates coordination and strategic planning;
- The Chief Scientist advises the Government on major scientific issues.

The key department in research policy and funding is the Department of Innovation, Industry, Science and Research (DIISR), 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.

Research Funding

Apart from the direct funding by Departments of the public sector research agencies in their portfolios, and university funding through block grants, there are two major direct research-funding bodies: the ARC, which provides competitive funding for university researchers in all fields except medicine; and the National Health and Medical Research Council (NHMRC), which provides competitive funding in medical fields.

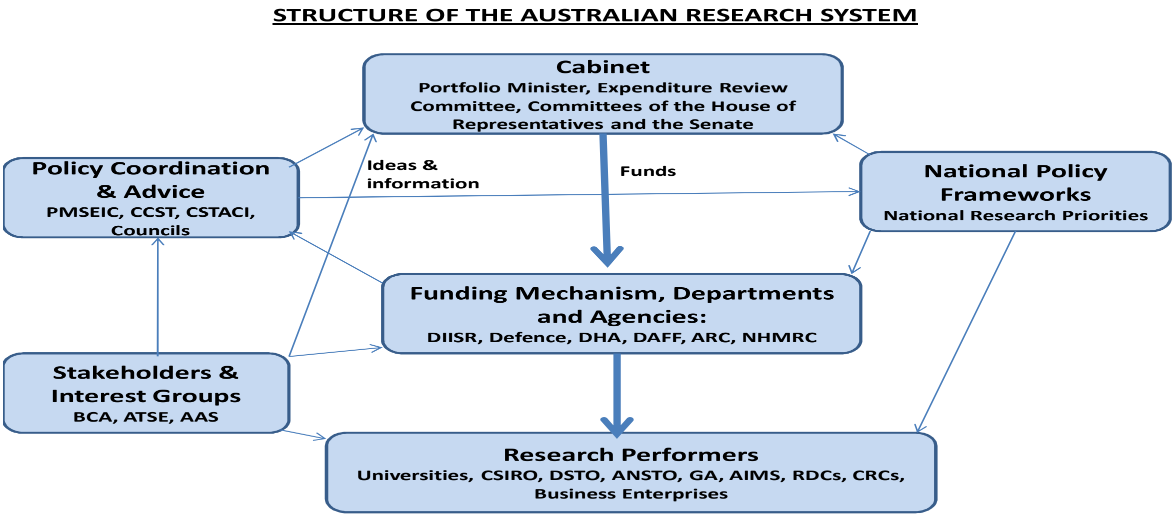
Research Performers

Over the past 15 years the major growth in research activity has been in universities, and in industry. The role of PROs has declined in relative terms. In addition to the universities (Universities Australia) the major public sector research performers are*:* the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Defence Science and Technology Organisation (DSTO), although several other sectoral research organisations are significant.

In practice, coordination within the research system is modest and there is no overall systematic and strategic research policy. While some initiatives (such as the CRC Programme and CSIRO's Flagships programme) have had some impact, there are not strong links between research and innovation policy, or (with some exceptions), between firms and research organisations.

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

Figure 1: Overview of the 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 2008-9. Over half (55%) of GERD in 2008–09 was conducted by firms and research actors located within two states, NSW and Victoria (see ERAWATCH Research Inventory, Australia Country Fiche 2011).

For some purposes, biophysical regions or economic regions are the unit of focus for regional policy. For example, in 2009 the Department of Innovation, Industry, Science and Research, established an Innovative Regions Centre to work in ten long established but less dynamic industrial sub-State regions. A Commonwealth Department of Regional Development and Local Government was formed in 2011, aiming to lead a more active national regional policy.

2.2 *Resource mobilisation*

This section will assess the progress towards national R&D targets, with particular focus on private R&D and of recent policy measures and governance changes and the status of key existing measures, taking into account recent government budget data. The assessment will include also the human resources for R&D. Main assessment criteria are the degree of compliance with national targets and the coherence of policy objectives and policy instruments.

2.2.1 Resource provision for research activities

Australia's GERD (€20.2b and 2.2% of GDP in 2008-9) grew at 6.1% (CAGR in real terms) since the mid 1980s. Over that period BERD had grown at 9.4% CAGR. While there has not been an explicit target for GERD, BERD or expenditure on education, policy documents continuously compare Australian performance with the 'OECD average' and the top performers in the OECD. GERD/GDP has increased from 1.43% in 1998-99 to 2.21% in 2008-9.

Funding for most PROs and research funding bodies is on a tri-annual basis. In 2002 the Government announced Australia's first National Research Priorities as a way of focusing public funding on areas relevant to major economic, social and environmental challenges. This set of priorities was developed with little formal prior analysis and consultation, but due to its inclusiveness has not been contentious. Australian Government organisations conducting or funding research are required to develop plans to address these priorities and to report on progress in their Annual Reports. The role of the national research priorities in research funding is currently under review by DIISR. There are also periodic reviews of research performing agencies or research funding bodies, and of specific fields of research.

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'.

Table 1: Australia's Innovation Priorities of 2008

Priority	Goal
Public research funding supports high-quality research that addresses national challenges and opens up new opportunities.	Increase proportion of research at world-class levels.
Australia has a strong base of skilled researchers to support the national research effort in both the public and private sectors.	Increase higher degrees by research completions by 2020.
The innovation system fosters industries of the future, securing value from the commercialisation of Australian 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 collaborations on research and development.	Increase international research collaboration.
The public and community sectors work with others in the innovation system to improve policy development and service delivery.	Raise public and community sector innovation.

Source: Cutler, 2008: 141-147.

Competitive vs. institutional funding and national research priorities

The main funding mechanisms are identified in Section 2.1. 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. The distribution of Commonwealth government research funding is complex. About 30% 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 24% 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 about 40% of Commonwealth R&D support, almost equally divided between performance-based block grants and competitive project-based funding. Universities also gain research funding through the CRC Programme, the RDCs and other schemes. The outcomes of the recent development of more systematic assessment of research quality will become the major criteria for the performance assessment for block grants to universities. In practice, due to the importance of publication 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.

In 2002, the Government announced Australia's first National Research Priorities with the aim of 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.

Recent Policy Developments in Response to Policy Reviews

Some of the recent research policy developments involve the realisation or elaboration of initiatives foreshadowed in *Powering Ideas: An Innovation Agenda for the 21st Century* (Commonwealth of Australia, 2009), a ten-year plan to strengthen the national innovation system, and is the Government's response to the review of Higher Education (Bradley, 2008). To pursue these goals the Government's investment in science and innovation in the 2009-10 budget increased by 25% from the previous year. The majority of this new funding was not closely linked to the new policy statement. Some arising from earlier initiatives included substantial funding increases for: space and astronomy (€117m); marine science (€128m); a bionic eye research programme (€36m over four years); and a 'Future Industries' initiative (€370m) including developing a National Enabling Technologies Strategy. The major new funding directly linked to the *Powering Ideas* policy statement included: the Commercialisation Australia (€143m); Super Science Fellowships (€20m); and a Collaborative Research Networks programme for regional universities (€39m). In addition, in the 2009-10 budget, new funding to universities included: doubling the amount of funding for the indirect costs of research; raising the rate of indexation for research block grants and scholarships; widening the eligibility of scholarships to international students; and undertaking an assessment of the quality of research. It is also proposed that the R&D tax concession scheme for business, operating since 1985, be replaced with an R&D Tax Credit.

In February 2011, the National Enabling Technologies Strategy was announced. The strategy has funding of €28m (A$38.2 m) over four years. It builds on the work of the earlier National Biotechnology Strategy (NBS) and National Nanotechnology Strategy (NNS). An Expert Forum of eight people has been established to guide the strategy's technology foresight activities. The Forum aims to help policy makers and regulators prepare for future developments relating to enabling technologies and also contribute to improving how science and technology are used by industry, government and society in general. The Forum will identify challenges arising in the next 5 to 10 years from new and converging enabling technologies, through consideration of research and development, and its possible application in Australia.

Building Mutual Trust between Science and Society

In 2009, the Government commissioned 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 funding to develop 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 proposed radio-astronomy facility the SKA) pre-competitive research where there is a strong emphasis on building research capacity (for example the National Enabling Technologies Strategy, (DIISR, 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 has been formed to facilitate collaboration, particularly domestic collaboration.

2.2.2 Evolution of national policy mix geared towards the national R&D investment targets

Evolution and Structure of BERD

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. This entitlement policy regime has been neutral with regard to sectors.

Expenditure on R&D by Australian businesses in 2008-9 was €12.3b – Table 2. BERD as a proportion of GDP increased from 1.26% in 2007-8 to 1.34% in 2008-9. While Australia's BERD/GDP ratio for 2008-09 remained below the total OECD average ratio of 1.63%, at the current rates of growth it is likely to soon exceed it – despite sustained growth in Australia’s GDP. Whether this continued growth in BERD is achieved will depend on the continued restructuring of the economy, the continued growth of the Chinese economy and the success of the new R&D Credit Scheme. In 2008-9 almost all (97%) expenditure for R&D by the business sector (BERD) was spent within the business sector.

Table 2. Business resources devoted to R&D

	2005-06	2006-07	2007-08	2008-09
Expenditure on R&D €m	7,616	9,226	10,881	12,305
Annual Growth % (nominal)	20	21	18	13

Source: ABS, 2010c

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 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 and Mining were the largest contributors to BERD in 2008–9, investing €3.2b (26%) and €3.17b (25%), respectively. Professional, scientific and technical services (€1.1b or 15%) and Financial and insurance services (€1.5b or 12%) were the next largest contributors. These four industries combined accounted for almost 80% of total

BERD. Of all industries, Mining (up €630m) reported the largest increase in BERD from 2007–8, followed by Financial and insurance services (up €430m).

In 2008–9, businesses with 200 or more employees made the largest contribution to BERD (71%) and accounted for 80% of the growth in BERD between 2007–8 and 2008–9. Businesses with 20–199 employees accounted for 17% of BERD. Surprisingly, the largest percentage increase in BERD (27% growth between 2007-8 and 2008-9) was recorded for small businesses with 5–19 employees. The growth in R&D in these small firms was largely due to the growth of business services (in large part IT and business advisory services) and to the mining sector (in which R&D by these small firms increased by 40% over this period).

The business sector was the main source of BERD funds in 2008–9, with over 95% coming from own funds. Other sources were: 2% from other business; 2% from Commonwealth government and 1% from overseas sources. Own funds were the only source of funds to show an increase in its proportional share of total BERD in 2008–9 (up from 93% of total BERD in 2007–8). As was the case in 2007–8, businesses in the ‘Health care and social assistance’ and the ‘Professional, scientific and technical services’ industries had the lowest proportions of self-funded research in 2008–9, at 50% and 80%, respectively. For all other industries, more than 90% of expenditure on R&D was self-funded by businesses.

Wholly Australian owned businesses made the largest contribution to BERD (46%) and the largest expenditure growth from 2007–8. Minority foreign-owned businesses accounted for 19% of BERD in 2008-9 and majority foreign-owned businesses accounted for 34.7% - a decline from the 36.5% in 2006-7. With the sustained and broadly-based growth in BERD for over ten years, and the likelihood of continued growth of GDP, continued growth of BERD is likely.

Funding from business enterprises accounted for 5% of HERD in 2008-9, a decline from the 5.7% in 2004-5. 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 2008-9.

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. Australia currently has a broad-based, market-driven tax concession, which allows companies to deduct up to 125% (the level has varied over time) of qualifying expenditure incurred on R&D activities when lodging their corporate tax return[2]. The current R&D tax concession does not apply where the IP generated through R&D will be owned offshore.

However, as part of the 2009-10 Budget, the Government announced the intention to replace the R&D Tax Concession with an R&D Tax Credit following the recommendations of the Review of the National Innovation System (Cutler, 2008). Legislation is before Parliament to replace the tax concession scheme (which has existed since 1985).

---

[2] The characteristics, role and limitations of the R&D tax concession are discussed in more detail in ERAWATCH Research Inventory, Australia Country Fiche 2011 at http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/

The new 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, and; a 40% non-refundable tax credit (equivalent to a 133% concession) available to firms with an annual turnover of €14.5m or more. The scheme would increase the base-rate of government assistance for R&D.

There has been a succession of schemes to stimulate private investment in high-risk ventures, particularly early stage ventures. Some of these schemes (for example the Pre-Seed Fund) have been replaced by the more direct granting mechanisms of Commercialisation Australia, but three venture-capital-related schemes remain[3].

The nominal value of funding from business enterprises for R&D in the Higher Education sector has increased over the past 20 years – but by 2008-9 accounted for only 2% of BERD. The increase of funding has, in part, been driven by funding programmes such as the Cooperative Research Centres Programme and the ARC Linkages Programme that co-fund projects in research organisations and require partial funding from business or other non-research organisations. Only 1% of BERD in 2008-9 was allocated to expenditure in PROs. Business funding of research in universities grew strongly from the early-1990s, and while the absolute level of funds has continued to grow, the share of HERD has not. The 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.

Other policies that affect R&D Investment

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. Participation in public sector and private sector projects is encouraged through the Australian Industry Participation National Framework —which encourages a consistent approach to maximising Australian participation in investment projects here and overseas; the Supplier Access to Major Projects Programme —which matches Australian suppliers to project opportunities; the Industry Capability Network —which makes information about Australian industry capabilities available to the proponents of major projects; and the Enhanced Project By-law Scheme —which requires proponents applying for tariff concessions to develop and implement an Australian industry participation plan. The government's ICT procurement policies were reviewed in response to the Review of the Australian Government's Use of Information and Communication Technology (Gershon, 2008). Consequently in 2010, the Government announced the establishment of 'The Government and Industry Principles of Engagement on ICT' (Department of Finance, 2010)[4]. These outline the expected standards and behaviours for all members of the Australian Government's value chain including Government agencies/bodies and suppliers. A clarification of

---

[3] For details see ERAWATCH Research Inventory, Australia Country Fiche 2011 at http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/

[4] http://www.finance.gov.au/procurement/ict-procurement/government_and_industry_principles_of_engagement_on_ICT.html

policy, Commonwealth Procurement Guidelines was set out in the Department of Finance and Deregulation (2008) Commonwealth Procurement Guidelines (2008).

2.2.3 Providing qualified human resources

The overall engagement of human resources in R&D (Table 3) has grown strongly over the nine-year period 2000-1 to 2008-9, 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 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 2008-9. This proportion is likely to grow further due to the strong growth in support for research in the higher education sector.

Table 3: Gross Human Resources (PYE) devoted to R&D, by sector

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

Source: ABS, 2010b

Australia is among the top third of OECD countries in terms of several research-related human resource indicators, such as the PhD graduation rate (1.9% of the age cohort), tertiary education expenditure as a proportion of GDP, and overall human resources in science and technology. The number of students completing higher degrees by research grew strongly in the early 2000s but has grown little since 2005. Australia is much lower in the rankings in terms of 'science and engineering university graduates as a percentage of total university graduates' (20.4%) –in part reflecting the structure of Australian industry– and R&D personnel as a percentage of total employment (1.23%), reflecting the modest GERD/GDP ratio[5].

The government policy statement, Powering Ideas (Commonwealth of Australia, 2009), included a goal of significantly raising the number of students who complete higher degrees by research. Particular priority is given to research degrees in science and engineering – in 2007 only 20.4% of new university graduates were in science and engineering.

Knowledge Triangle Policy Linkages

Skills Australia was established in 2008 in the Government's Skilling Australia for the Future policy to provide advice on current, emerging and future workforce development needs and workforce skills needs, including identifying training priorities to increase workforce participation and improve productivity and competitiveness. Skills Australia undertakes or commissions a wide range of research to inform education and training policy. In 2009, the government announced a ten-year higher education reform strategy in the key reports: *Transforming Australia's Higher*

[5] For further detail see ERAWATCH Research Inventory, Australia Country Fiche 2011 at http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/

Education System (Bradley, 2008) and *Powering Ideas: An Innovation Agenda for the 21st Century*. This strategy includes the development of 'mission-based compacts'[6] with universities which will specify the types and levels of performance which the government expects of universities and include (to an extent yet to be clear) research output, research quality and 'third mission'/engagement objectives. There has been a particularly strong focus on the quality of research in universities.

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

- The Australian Postgraduate Awards (Industry) (APAIs)[7] are awards for higher degrees for research carried out in the context of Linkage Projects funded by the ARC and carried-out in collaboration with a non-university research partner. In 2009 362 APAIs were funded.
- A Commercialisation Training Scheme (CTS)[8] was introduced in 2007 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 CTS is currently being reviewed.
- The Government Enterprise Connect Programme operates a *Researchers in Business* Scheme, which funds up to 50% of salary for researchers employed in small and medium sized business for a period of 2 to 12 months. The Scheme commenced in 2009 and is designed to help breakdown the cultural divide between business and the research sector and disseminate expertise.

The vocational education and training (VET) system, which is largely under State jurisdiction, has not had the level of policy focus of the university sector. However, with increasing concerns about skill levels and shortages a national framework for the VET system, within the National Skills Framework, is under development. This includes a number of components which aim to provide nationally recognised skills standards, qualifications and quality assurance for training organisations - for further detail see ERAWATCH Research Inventory, Australia Country Fiche 2011[9]

The VET system is generally considered to have worked well, despite the complex division of responsibilities (OECD, 2008a). But there is less confidence that the system is adequate for a range of new challenges. A recent discussion paper by Skills Australia (2010) suggests that the current approach does not provide the broad knowledge and skill that can underpin both the needs of emerging industries and continuous upgrading and re-skilling.

Policy toward lifelong learning has not been a strong feature of the education debate in Australia, largely because the perception is that the education system is open and supports lifelong learning (Karmel, 2004). There has been increasing concern that those with poor basic education (low socio-economic groups, indigenous communities and some migrants) face declining employment opportunities and limited capacities to make effective use of existing education and training facilities.

---

6 http://www.innovation.gov.au/Research/MissionBasedCompacts/Documents/Missionbasedcompactsexplanatorypaper.pdf

7 http://www.arc.gov.au/ncgp/lp/lp_default.htm

8 http://www.innovation.gov.au/AboutUs/KeyPublications/PortfolioFactSheets/Documents/COMMERCIALISATION-TRAINING-SCHEME.pdf

9 http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/,

Main Societal Challenges

The adequacy of the future research workforce has been raised in a number of reviews and DIISR is working on a national research workforce strategy to 2020 (DIISR, 2009b, Hugo & Morriss, 2010)[10] – see Section 3.1 below.

Evidence from a number of surveys suggests that linkages, among firms and between firms and research organisations, are relatively weak in Australia (DIISR, 2010a). ABS (2008a), which provides information on gaps in the human resources for innovation as reported by business, indicates that on average shortages are most significant in trades and information technology, and least significant in scientific and research skills areas. However, among larger firms, possibly undertaking more demanding types of innovation, shortages in engineering skills were significant.

More broadly, 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. Two recent reports (Commonwealth Parliament, House of Representatives, Standing Committee on Industry, Science and Innovation, 2008, 2010) indicate that in a few cases some universities and other employers of researchers encounter problems with the immigration processes.

An audit in 2006 found that the proportion of domestic students in SET study across all education and training sectors had remained static or declined over the previous decade -particularly in the enabling sciences of advanced and intermediate mathematics, physics and chemistry. The declining completions in SET is leading to a decreasing pool of applicants for SET positions in industry and the scientific research sector (DEST, 2006). Participation in senior secondary school science has declined over the 30-year period from 1976 to 2007. As the uptake of science-related studies at university is related to what happens in secondary school (and possibly at earlier stages) the quality of courses and teachers is a driver of participation in science and engineering courses at university (Ainley, et al., 2008). These issues have led to a number of initiatives, some led by the science and technology-related academies, to improve science teaching in primary and secondary schools[11].

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. A study of ‘employability’ skills carried out by the Australian Chamber of Commerce and Industry and the Business Council of Australia (DEST, 2002). Similar studies inform policy in the VET and Higher Education sectors (Precision Consulting, 2007; Rigby, 2009). At this stage the response to these concerns has been largely pursued at individual education organisations and through the development of curricula requirements for accreditation by professional bodies.

Entrepreneurship education has had a surprisingly slow start in Australia (Chan, 2005). From the early 2000s a growing number of universities were offering

[10] The strategy development 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’(Commonwealth Parliament, House of Representatives, 2008)

[11] See: http://www.science.org.au/primaryconnections/; http://www.science.org.au/sciencebydoing/index.htm; http://www.scientistsinschools.edu.au/; http://www.stelr.org.au/

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 *Knowledge demand*

This section focuses on structure of knowledge demand drivers and analysis of recent policy changes.

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 (DIISR, 2010b). The key characteristics of this structure are:

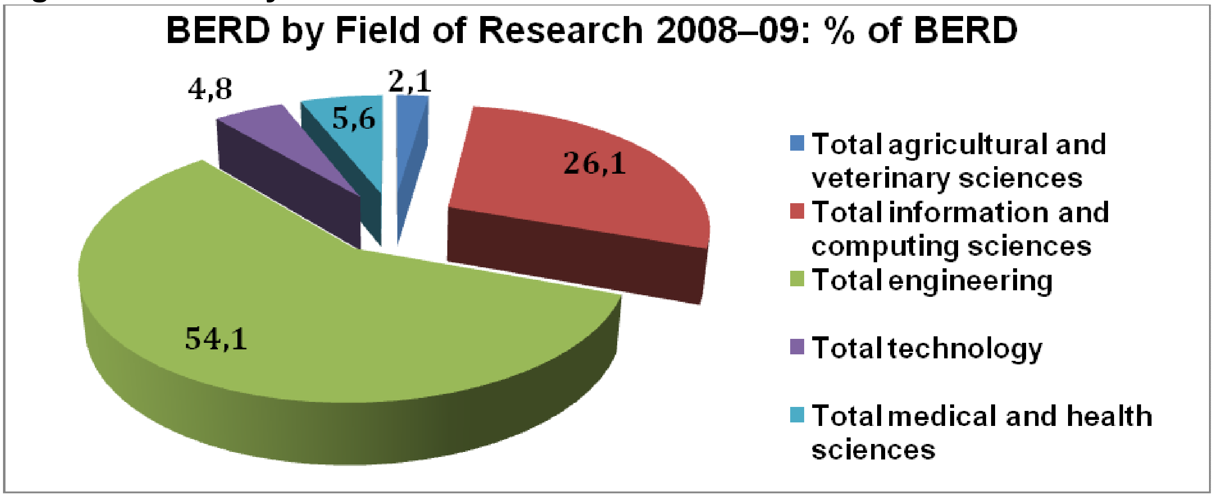
- The relatively large contribution of mining and agriculture to GDP and the relatively low contribution of manufacturing;
- The dominance of low and medium-technology sectors within manufacturing;
- A relatively small 'high technology' manufacturing sector accounting for less than 1% of GVA in 2005 (most recent data);
- A relatively high proportion of foreign-ownership of industry - Enterprises with greater than 50% foreign ownership accounted for 34.7% of BERD in 2008-9;
- A relatively small role of trade in GDP –smaller than in many other small and medium sized open economies; and
- A relatively large proportion of small firms.

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

- The sustained decline in the role of manufacturing, declining from almost 18% of GDP in 1978 to 10.7% in 2008;
- The growth in knowledge-intensive business services from 14.4% of GDP in 1978 to 23.8% in 2008;
- Growth in mineral exports, from 30% of exports in 1990 to 50% in 2009.

As a result, the resources industries, particularly mining, play a major and increasing role in the Australian economy, as outlined in Section 2.2.2, Knowledge demand is also shaped by the strong growth of R&D in the service sectors (which account for almost 50% of BERD). The R&D-intensive 'high tech' manufacturing industries in many OECD economies, and particularly large firms in those industries, account for a major share of both BERD and of research collaboration with PROs and universities. According to UNCTAD (2005) 700 firms with the largest expenditure on R&D are responsible for almost half the world's total R&D expenditure and over two thirds of business R&D – very few of those firms are in Australia. The particular characteristics of the Australian economy provide part of the explanation for the low BERD and the relatively low levels of research-industry collaboration.

Figure 2: BERD by field of research



Source: ABS (2010c)

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. As shown in Figure 2, in 2008-9 BERD was largely in the research fields of Engineering (54%) and Information and computing sciences (26%).

Australia has received on average €18.2b of FDI inflows each year since 2001. The US dominates the stock of FDI in Australia accounting for 24% in 2008, followed by the UK (15%), Japan (9%), and the Netherlands (6.4%). FDI from China and India is growing steadily. Total investment inflow in 2008 was about €100b, with the largest share from the US (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 major priority in the Government's innovation agenda (OECD, 2008). Low carbon and renewable energy programmes shared 32% (€2.4b) of the major R&D granting programmes and other support for science and innovation in the 2010-11 Budget – an increase of 290% on the previous year. The Clean Energy Initiative, the Green Car Innovation Fund, the Global Carbon Capture and Storage Institute, the Low Emissions Technology Demonstration Fund and the National Clean Coal Initiative together accounted for 76% of the allocation of funding for programmes and other support for science and innovation (DIISR, 2010a) – i.e. funding outside the allocations to PROs and research granting schemes.

Table 4: Government Expenditure for Science, Research and Innovation 2010-11 by Socio-Economic Objectives (%)

01. Exploration and exploitation of the earth	*5.0*
02. Environment	*4.5*
03. Exploration and exploitation of space	*0.8*
04. Transport, telecommunication and other Infrastructures	*4.0*
05. Energy	*6.9*
06. Industrial production and technology	*20.9*
07. Health	*14.7*
08. Agriculture	*6.0*

09. Education	*0.3*
10. Culture, recreation, religion and mass media	*1.0*
11. Political and social systems, structures and processes	*2.8*
12. General advancement of knowledge: General University Funds	*16.8*
13. General advancement of knowledge: non-GUF sources	*10.6*
14. Defence	*5.6*
TOTAL	100.0

Source: DIISR, 2010d

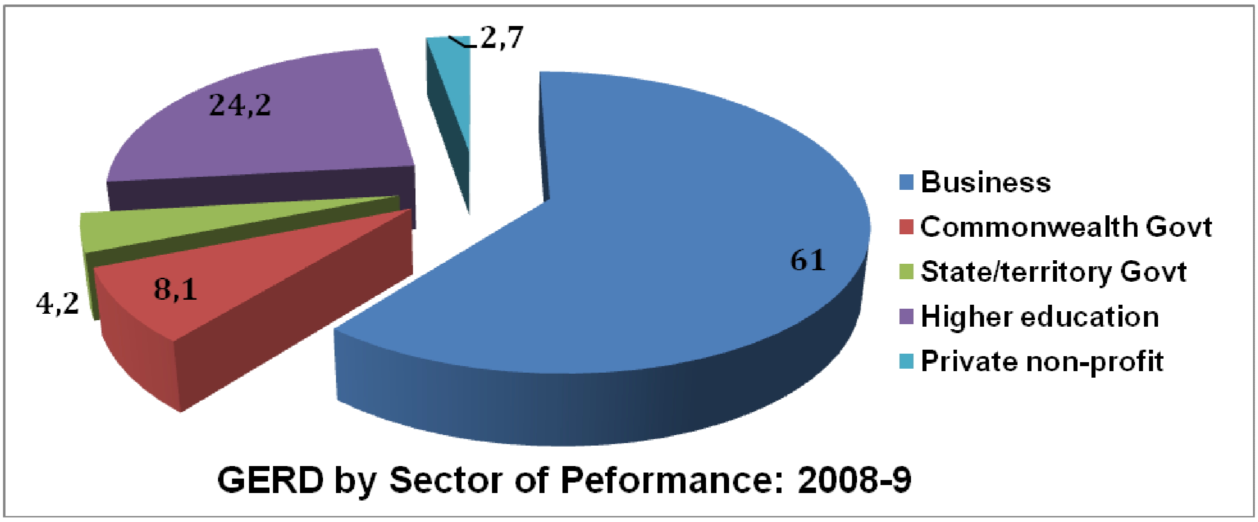
2.4 *Knowledge production*

The production of scientific and technological knowledge is the core function that a research system must fulfil. While different aspects may be included in the analysis of this function, the assessment provided in this section focuses on the following dimensions: quality of the knowledge production, the exploitability of the knowledge creation and policy measures aiming to improve the knowledge creation.

2.4.1 Quality and excellence of knowledge production

Investment in knowledge at 3.9% of GDP (2004) ranked Australia eighth among the 18 OECD countries, but significantly below the OECD average for that year. In 2008-9 GERD was €20.2b, an increase of 27% over 2006-7. Over the ten years to 2008-9, GERD has more than tripled. GERD/GDP increased from 2% in 2006-7 to 2.21% in 2008-9. As shown in the chart below, 61% of GERD is expenditure by business enterprises (BERD) and 24% is expenditure in the Higher Education sector (HERD). In terms of output indicators, Australia ranks 9th in the OECD in publication-intensity and share of world publications, but considerably lower (16th) in terms of publication citation rates. The extent of new-to-the-world product innovations by Australian firms is near to the bottom of the range among OECD countries –reflecting the relatively low level of manufactured exports by domestic firms – for details see ERAWATCH Research Inventory, Australia Country Fiche 2011[12].

Figure 4: GERD by Sector of Performance, % of total



Source: ABS, 2010c

[12] http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/

2.4.2 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[13]. 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 block grants to performance assessments based on the Excellence in Research for Australia (ERA) assessments –a comprehensive evaluation of research performance. The Australian Research Council (ARC) has been designing and developing ERA in consultation with the sector since early in 2008. The ERA evaluates research activity in Australian higher education institutions at a discipline level using a combination of indicators and expert review. The ERA will be taken into account in the Sustainable Research Excellence (SRE) Programme from 2012. The eligibility of institutions for funding from the SRE Programme will be contingent on their participation in ERA. The first comprehensive ERA assessment was completed in 2010 and this provides a ranking of the disciplines in each university against world benchmarks.

The ongoing debates are about the appropriate assessment of 'excellence' and 'impact' in the evaluation of university performance. In the early 2000s there was a focus on the assessment of the commercialisation performance of universities, based on very narrow indicators (licences, spin-offs, commercial income). The government is also planning the development of 'mission-based compacts' to be negotiated with each university, and to include 'third mission' activities.

Competitive grants for public sector research involve extensive peer review, often including international assessors. This includes funding for university research through the Australian Research Council (ARC), for university and medical institute research through the National Health and Medical Research Council (NHMRC), and for a range of public sector research organisations through the CRC Programme.

2.5 *Knowledge circulation*

This section provides an assessment of the actions at national level aiming to allow an efficient flow of knowledge between different R&D actors and across borders.

2.5.1 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. For example, the proportion of large firms collaborating with universities (10%) is among the lowest in the OECD. The level of interaction varies across sectors and it is the mining industry, dominated by large firms, that has the highest level. Small firms have a major role in the Australian economy with contributions to gross value added (47.6% in 2007) and employment (53.1% in 2007) above the OECD averages (44.9% and 50.4% respectively) (DIISR, 2010a). According to the 2005 Innovation Survey, 3.1% of SMEs collaborated with universities for innovation –at the lower half of the range among OECD countries (ABS, 2006). As shown below, most of the other indicators of direct knowledge exchange between industry and research organisations are toward

[13] http://www.innovation.gov.au/Science/ResearchInfrastructure/Pages/NCRIS.aspx

the lower end of the range among OECD countries. Collaboration among researchers at different universities – based on the level of co-authorship of publications - increased from 27% in 1996-2000 to 31% in 2001-2005.

Table 6: Australia's relative performance in knowledge exchange

Indicator	Performance	Year	OECD Rank
Innovation-active firms collaborating with universities	1.6%	2006-7	
Innovation-active businesses collaborating with PROs	7.2%	2006-7	
SMEs collaborating in innovation with universities	3.1%	2004-6	13th
SMEs collaborating in innovation with PROs	2.9%	2004-6	9th
Large firms collaborating in innovation with universities	10.0%	2004-6	20th
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	€156m	2007	
Gross income from contracted research by publicly funded research organisations and universities	€0.73b	2007	
Share of patents owned by universities & government	7.0%	2003-5	8th
HERD financed by business	6.7%	2006	12th
GOVERD financed by business	12.1%	2006	7th

Source: DIISR, 2010a

The policy statement, *Powering Ideas: An Innovation Agenda for the 21st Century*, (Commonwealth of Australia, 2009) included the adoption of seven National Innovation Priorities, including one-concerned increasing intra-national linkages.

There are two important and long-standing mechanisms both of which aim to provide incentives for the universities and public sector research organisations to collaborate with business or other users: the ARC Linkage Programme; and the Cooperative Research Centre (CRC) Programme. In addition, the NHMRC Partnerships for Better Health programme supports collaboration between researchers and decision-makers in the health system, with a view to strengthening evidence-based policy and decision-making. A broader understanding of the many paths for knowledge transfer has broadened the policy focus from an earlier narrow pre-occupation with spin-offs and licensing. In the early 2000s there was a strong focus on the assessment of the commercialisation performance of universities, based on very narrow indicators (licences, spin-offs, commercial income). At the present stage universities focus more on the 'excellence' of their research rather than commercial impact. The Commercialisation Training Scheme (CTS) and the *Researchers in Business* Scheme are two recent initiatives which aim to promote knowledge transfer and commercialisation. The most recent review of the CRC Programme (O'Kane, 2008) lamented the limited extent of industry participation and criticised the emphasis placed by the programme managers on direct commercialisation. It proposed new initiatives to engage with a wider range of potential industry partners, particularly SMEs, and a broader concept of value creation, less focussed on commercial returns. More broadly, it is widely recognised that the limited extent and depth of linkages within the innovation system is a challenge for policy.

2.5.2 Cross-border knowledge circulation

International collaboration has become increasingly important for Australian research, and increasing that collaboration is an explicit policy priority – although there is little or no strategic framework for such collaboration.

However, Australia is toward the bottom of the OECD rankings on indicators of international knowledge exchange[14]. In the case of the proportion of HERD financed from abroad, the level has steadily **declined** from 2002, while the number of formal inter-university international agreements has increased steadily. However, these indicators also show the extent to which Australia benefits greatly from the high inflow of tertiary educated migrants. Foreign born researchers are often active in developing collaboration with their country of origin. The relatively large role in Australian industry of firms with overseas parents also contributes substantially to knowledge flows, but the proportion of Australian business collaborating with overseas businesses is one of the lowest in the OECD.

Within the Government, DIISR, through the International Science Linkages (ISL) Programme, has a lead role in instigating and managing intergovernmental science and research relationships. DIISR manages 30 science and technology agreements, of which 10 are active, and four have established bilateral science and technology reciprocal funds including with India, China, France and Japan. These agreements are implemented through bilateral joint committee meetings which identify priorities, select priority projects and discuss strategic directions.

The ISL also has some funding to enable researchers to develop projects or networks, which may lead to further support from the mainstream funding bodies. To 2010 ISL had funded over 600 projects enabling 3,000 Australian researchers to collaborate with researchers in 40 countries However, funding for the ISL Programme over the nine years 2002-3 to 2010-11 totalled only about €50m.

In addition to the activities of DIISR:

- Research funding agencies such as the ARC and NHMRC support international collaboration - over half of the total number of projects funded by the ARC in 2009 involved international collaboration.
- Government funded research agencies, such as the CSIRO, conduct research with international engagement; and
- Other Commonwealth Government departments pursue country agreements in specific thematic areas for which they have responsibility.

The Government has sought to 'internationalise' major research programmes to reduce the structural barriers to international collaboration. The ARC, as part of an evolving international strategy, now provides greater direct support for international collaboration. As detailed further below, both CSIRO and the CRC Programme encourage international research collaboration[15]. Australia is collaborating with the multi-country "ACCESS4EU" initiative, led by the International Bureau, German Federal Ministry of Education, which aims to develop a standard database

---

[14] For details see ERAWATCH Research Inventory, Australia Country Fiche 2011 at http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/

[15] For details see ERAWATCH Research Inventory, Australia Country Fiche 2011 at http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/

architecture to make it easier to understand and compare different nations' research funding arrangements.

Research Collaboration between National and Foreign Research Organisations

All major PROs and universities have formal and informal international collaboration arrangements – and the government encourages them to do so. For example, the CSIRO had 73 relationship agreements such as memoranda of understanding with partner research organisations and firms in 19 countries in 2008-9. In 2008-9, it was engaged in almost 700 collaborative activities covered by contracts (not including publications) with partners in 66 countries. Collaboration with the US and Europe accounted for over 45%, and China a further 9%, of international projects over the past four years. About 45% of CSIRO's peer-reviewed scientific publications in 2008 were co-authored with partners and collaborators overseas. Most of the Cooperative Research Centres have some form of formal international research cooperation.

Participation of National Teams in Projects Involving Inter-Governmental Research Infrastructure

Access to major international research facilities has long been an important aspect of research policy. As Australia invests more heavily in developing national research facilities it aims to strengthen two-way collaboration. Specific support under the national research infrastructure funding programmes included funding Australia's associate membership in the European Molecular Biology Laboratory (EMBL) and Australia's partnership in the Giant Magellan Telescope (GMT) located in Chile. DIISR is actively supporting the international initiative to develop a Square Kilometre Array radio telescope, and has committed €80m to a pilot facility.

The ARC supports access by Australian researchers to international research facilities and initiatives. Under this scheme in 2010 the ARC supported access by Australian researchers to six international research facilities or projects.

Individual Research Mobility

Through the International Postgraduate Research Awards (IPRS) the ARC also support almost 1000 scholarships per annum for overseas students to undertake post-graduate research degrees in Australian universities. Recipients come from a wide range of countries, for example in 2009 about 12% were from China, 8% from Germany and 5% each from the US, Bangladesh and Singapore.

Recent changes to the ARC National Competitive Grants schemes also increase international access and collaboration. These include:

- Discovery Projects: PhD stipends may now be held by applicants who are not Australian citizens; Outstanding Researcher Awards (DORA) are open to non-Australian citizens, although successful applicants must reside predominantly in Australia; International Collaboration Awards to support travel and living costs for international collaboration and collaborators within projects.
- Linkage Projects: funding is permitted for international travel to foster and strengthen collaborations between researchers in Australia and overseas; and Partner Organisations may be overseas organisations including overseas higher education organisations
- The Future Fellowships scheme and the Australian Laureate Fellowships scheme will allow applicants who are non-Australian citizens as long as the application is through an Australian eligible organisation and the Fellow resides largely in Australia.

2.5.3 Main societal challenges

The specific 'grand societal challenges' identified in the Lund Declaration are also issues on the research policy (and broader policy) agenda in Australia. This is reflected clearly in the National Research Priorities. Over the past five years the issues of climate change and clean energy have been a particular priority, and recent initiatives are discussed further below.

The policy priorities that are expressed through the specific objectives and initiatives of the Innovation Union Flagship Initiative are also priorities for research and innovation policy in Australia. The policies which aim to address these concerns have most recently been expressed in the Government White Paper *Powering Ideas: An Innovation Agenda for the 21st Century*, and progress in achieving the policy objectives is assessed in the Australian Innovation System Report 2010 (DIISR, 2010f). The specific initiatives relevant to the Innovation Union priorities are discussed below: promoting collaboration between research and industry is discussed in Section 2.5.1; ensuring an adequate and appropriate supply of human resources is discussed in Section 2.2.3; and measures to promote private sector investment in R&D are discussed in Section 2.2.2.

Climate Change and Clean Energy Initiatives

Australia accounts for about 1.5% of global greenhouse emissions, approximately 70% of which come from the production and use of energy. A carbon tax policy was announced in 2011, but climate change policy remains highly politically contentious. While a range of initiatives has been introduced to promote energy efficiency, to date the major effort has been directed to 'clean energy' programmes.

Government policy mandates that by 2020, 20% of electricity consumption will be from renewable energy sources – this increased the target of the Renewable Energy Target (RET) scheme. The government is also investing €3.65b in the Clean Energy Initiative (CEI) to support the development of clean energy and energy efficiency technologies. The two largest components of the CEI, both aimed at supporting commercial scale pilot plants, are the Carbon Capture and Storage initiatives (including the €1.35b Carbon Capture and Storage (CCS) Flagships Programme), and the Solar Flagships Programme with funding of €1.1b for large scale, grid connected, solar (thermal and photovoltaic) power stations. The CEI also supports two more research oriented initiatives: €110m for the Australian Solar Institute (ASI) and €500m for the Australian Centre for Renewable Energy (ACRE) promotes the development, commercialisation and application of renewable energy technologies.

In addition a Low Emissions Technology Demonstration Fund (LETDF) operated up to 2006, and planned to invest over €350m, along with private investors, to help Australian firms commercialise world-leading low emissions technologies. In 2007 the Council of Australian Governments (COAG) also announced the development of technology roadmaps to advance clean energy, and three roadmaps have been completed:

- Geothermal Industry Development Framework
- Australian Geothermal Technology Roadmap
- Hydrogen Technology Roadmap.

2.6 *Overall assessment*

Resource Mobilisation. With the benign economic context of the past decade, BERD and GERD have sustained high growth. The incoming government in 2008 increased public investment in R&D, largely in higher education R&D, and initiated a range of research and innovation-related reviews. Following a review of the innovation system, an R&D tax credit scheme is proposed 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 and a Research Workforce Strategy are under development, and policy in the areas of international research collaboration and research priorities are currently under review.

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 steadily shrinking manufacturing sector), small firms and foreign-owned firms. Mining and services firms are increasing their share of BERD and of export activity. There is a ‘mismatch’ in the areas of focus of BERD and HERD. FDI into Australia is over €20b per annum and rising, 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 60% of GERD and HERD for a further 24%. There has been a strong investment in research infrastructure with the development of a long term research infrastructure development strategy and the creation of multi billion Euro investment fund, financed by past budget surpluses. Australia ranks towards the middle of OECD countries in terms of most indicators of research inputs, but toward the lower quartile in most indicators of research outputs – in part this reflects an economy with a small ‘high tech’ sector and a great deal of innovation through technology 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.

Knowledge Circulation. Increasing inter-firm and industry-research collaboration are priorities, although little has been done to boost such links. Industry structure and the nature of innovation limit such collaboration. International research collaboration is extensive, and significant for high quality research, and the research funding schemes are increasing support for such links. Higher education scholarship and fellowship schemes are now open to non-national applicants and research funding schemes more readily support international collaboration. The research workforce is highly international and becoming more so. Many researchers pursue opportunities overseas and there is a strong inflow of non-national researchers. The continuation of these inflows is vital for the future stock of researchers.

Table 7: Summary of main policy related opportunities and risks

Domain	Main policy opportunities	Main policy-related risks
Resource mobilisation	Continued strong economic growth, Powering Ideas, and other initiatives have led to increased funding for Higher Education research and infrastructure Initiatives increase the focus on Clean Energy Technologies and on Enabling Technologies. Proposed new incentives may increase investment in BERD.	The support for post-graduate students may not be a sufficient incentive in a growing economy. This may lead to future skill shortages at the researcher level. Investment in knowledge generation may not be linked to demand from industry.

Knowledge demand	The growth of BERD and of the resource and related infrastructure has increased research and the demand for skills in engineering and IT. Clean energy research has increased, as has coordination of R,D&D through the flagship programmes, ASI and ACRE.	The areas of research focus in the business sector and in the research sector may continue to diverge, as there are few mechanisms to prevent this, leading to skill shortages. This mismatch may become more acute if the service sector expands on the basis of exports.
Knowledge production	Government policy is focusing on the quality of research in HEIs and more closely linking funding to performance. The proposed tax credit scheme aims to focus greater support on SMEs.	An emphasis on standard research quality indicators may reduce: • Multidisciplinary research; • Applied research with users; • High risk novel research; • Incentives to link with SMEs. The Tax Credit scheme may be lead to unplanned problems that provide disincentives for some firms, including services firms.
Knowledge circulation	Greater domestic and international collaboration is a policy priority, but systematic measures to encourage this remain to be developed. Enterprise Connect and the CRC Programme **aim** to increase research collaboration with SMEs. Support for international collaboration is increasing.	Measures to raise the level of innovation activity in SMEs may not lead to increased collaboration. The emphasis on research quality may be a disincentive to collaboration with users. The transaction costs in the CRC Programme discourage user involvement. International research collaboration will continue with no strategic framework and generate few national benefits.

Table 8: Main barriers to R&D investments and respective policy opportunities and risks

Barriers to R&D investment	Opportunities and Risks generated by the policy mix
Capabilities in SMEs	SMEs have a major role in the Australian economy but many lack capabilities and strategies for innovation. Few policies in the past have addressed this problem. Enterprise Connect is likely to make a modest and gradual impact. The research quality focus will discourage universities from building collaboration with SMEs due to high transaction costs.
Carbon emission control	Australia has a relatively high intensity of carbon emissions in relation to population and GDP. Measures to reduce emissions may reduce the competitiveness of many export industries. While there is substantial investment in R&D the limited current market opportunities may constrain private sector investment in R&D.
Foreign-owned firms	Foreign owned firms have a major role in the export of high value manufactured products from Australia (e.g. automotive and pharmaceuticals). The rising value of the currency and skill shortages (with rising staff costs) may reduce the role of these subsidiaries in the strategy of the parent firms.
Managing industry re-structuring	The economy is continuing structural change with a growth of resources and services and a decline in manufacturing. The latter is a challenge for regional policy and may encourage forms of protection. The former is a challenge for the supply of skills. The nature of innovation in services may require new approaches to

	encouraging industry – research collaboration and to innovation incentives. At a broad level the resources boom may reduce the long-term dynamism and competitiveness of the economy, inducing short term complacency along with decline in the non-resource linked sectors.
Complementary assets	New firms forming in specialist product and service areas require access to international markets to sustain growth and build international competitiveness. While the resource sector provides a substantial domestic demand for some new suppliers of equipment and services, the broader role of demand-side innovation policy has not been developed. Programmes to assist small firms to access overseas markets are also little developed.

3 National policies which correspond to ERA objectives

3.1 *Labour market for researchers*

3.1.1 Stocks and mobility flows of researchers

The overall engagement of human resources in R&D has grown strongly over the 2000-1 to 2008-9, 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 2008-9 – 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[16]).

The Australian Government is currently developing a research workforce strategy, and this includes issues of researcher mobility. The strategy is being developed in response to issues raised in a number of reviews (DIISR, 2010e) examining research training and the research workforce. It will look ahead to 2020 and plan measures to help ensure that Australia is able to meet possible shortfalls in the supply of research qualified people. The strategy will also address concerns regarding the lack of clear career paths for research students and the adequacy of the research training system to prepare them 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'[17] (Commonwealth of Australia, House of Representatives, 2008). This aspect includes issues about internal and international mobility. A Reference Group with wide participation has been established to support the development process. A consultation paper was released for public comment in June 2010, and two studies were commissioned to guide the work.[18]

Access Economics (2010) estimated that almost 116,000 people aged 15-64 in 2009 hold postgraduate research qualifications. This stock is growing at about 9% per annum –despite the slow growth in the level of domestic completions of Higher Degrees by Research for several years (DIISR, 2010c). The stock has been significantly increased by migration. By occupation, some 78% of those employed with postgraduate research qualifications are estimated to be employed as professionals -academics account for nearly 51.2%. Around 0.5% of the 25 to 29 age cohort age group are studying for a doctorate-by-research in a given year. Over the decade to 2008, international doctorate-by-research completions grew at an annual rate of 8.1%. In 2008 international students accounted for 23% of all HDR completions. Many (probably close to 40%) of international students undertaking postgraduate study in Australia go on to obtain permanent residency, and therefore add to the stock of postgraduate research qualifications in Australia. The study

[16] http://erawatch.jrc.ec.europa.eu/erawatch/opencms/information/country_pages/
[17] http://www.innovation.gov.au/Research/Documents/ACDSpresentation19October2010.pdf
[18] http://www.innovation.gov.au/Research/Documents/EmployerDemandforResearchersinAustraliareport.pdf; and http://www.innovation.gov.au/Research/Documents/AustraliasFutureResearchWorkforce-SupplyDemandandInlfuenceFactorsStudy.pdf

estimated that 1.3% of non-student migrants are holders of PhD degrees. Projections of the likely trends in supply and demand for researchers estimate that demand may outstrip supply in a high growth/high innovation-intensity scenario, but for most scenarios an aggregate supply shortfall is unlikely.

The changing nature of demand for researchers involves issues of the increasing *scale* of demand (with increasing innovation-intensity); of shifting *scope (*field of research*)*; and of change in the *nature (*skill requirements*)* of demand. A particular challenge will be to address high levels of replacement demand (demand due to retirement) for research-qualified workers (Hugo & Morriss, 2010). Changes in the *scope* of demand may arise from, for example, improved environmental management, climate change mitigation and improvements to health science.

The primary vehicles of government funding for research training are the Research Training Scheme (RTS), Australian Postgraduate Awards (APAs), and International Postgraduate Research Scholarships (IPRS). Funding for these schemes amounted to over €580m in 2010, with the RTS accounting for the greatest proportion of funds. Most (about 75%) of the government programmes aimed at attracting and retaining domestic and international postgraduate research students are aimed at domestic students, although most are also available to both domestic and international researchers (DIISR, 2010b). The Commonwealth Government provides about €15m per annum to International Postgraduate Research Scholarships to attract top international postgraduate students to areas of research strength in Australian higher education providers. About 1000 IPRS scholarships are awarded each year. Scholarships are open to international students of all countries and are available for a period of two years for a research masters or three years for a research doctorate.

Recent comprehensive data on the mobility of researchers is not available. Birrell, et al (2004) estimate that over 2000-3, Australia had a net inflow of about 5,000-7,000 ‘scientists and technologists- i.e. ‘scientists, engineers and IT specialists’. The outflow slightly exceeded the inflow of returning Australian scientists and technologists in most years. Hugo (2008) estimates that in 2002-3 about 1,700 academics came into Australian universities while about 1200 academics left Australia –a net inflow of about 500. Hugo’s data show a strong increase in mobility since 2000. Hugo and Morriss (2010) provide data on arrivals and departures of academics over 2003-9, including both long-term and permanent movements. Overall, about 40% of academic staff in universities was overseas born, and the data indicates that inflows of long term and to lesser extent permanent residents substantially exceed outflows.

Birrell et al (2004) estimate that of the approximately 10,000 PhD graduates in Australia in Science, Health, IT and Engineering over the 1996-2001 period about 950 left Australia, permanently or temporarily, but that there was an inflow from overseas (including returning nationals) of about 1,850, resulting in a net inflow of about 1,200 people with PhDs.

Mobility between sectors is reduced by the challenges of re-entry to universities. Re-establishing an academic career is increasingly difficult without a current publishing track record, and salary levels in universities are often below those in other sectors.

Australian Universities, PROs and businesses actively recruit researchers from all countries on the basis of merit. A candidate selected on the basis of merit would generally have few difficulties obtaining a visa to work in Australia, although recognition of awards may delay the process in some cases. Many universities use the 457 (Temporary Business) Visa category. This allows them to appoint foreign researchers for up to four years and the researchers are eligible to apply for permanent residence once they are established in Australia. *The Australian Researchers' Mobility Portal* was developed to provide resources to researchers considering a move to or from Australia.

3.1.2 Providing attractive employment and working conditions

A recent study (Coates, 2009) 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. 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 is because Australian academic salaries are relatively uncompetitive with comparable private sector salaries in Australia and some overseas academic salaries. Surveys (e.g. DIISR, 2010e) indicate that Australian researchers who remain overseas do so largely because of higher research funding, a more supportive research environment and better salaries. Some universities are having difficulties filling positions at the top of the academic ladder. This is a major reason for some of the recent high level ARC Fellowship Programmes.

Lack of clarity over career pathways, poor management in universities, employment on a series of contracts and limited promotion opportunities contribute to dissatisfaction. With the continuing development of a competitive global market for researchers, along with greater researcher mobility, attractive working conditions and opportunities are essential –and there is growing awareness of these issues, which are now pursued through the research workforce strategy[19].

Many individual universities and research organisations support return to work after an employment break -usually targeted at women. One of few specific initiatives is the CSIRO Payne -Scott Award that provides a one-year grant to support mainly female researchers in re-establishing and re-connecting with the research underway in their field following a career break. However few have policies and measures aimed at supporting re-entry from a period of time in the business or government sectors. In the university sector the representation of women and men has reached parity up to Senior Lecturer level, but not at the more senior levels (DIISR, 2010b). There are no rules aiming at gender balance but there is strong encouragement of gender equity and extensive reporting of performance (Bell, 2009).

There has long been a concern that Australia may experience a 'brain drain'. There are schemes to encourage successful Australian researchers to return to lead research groups in Australia. However, there is also awareness that, with increasing mobility and collaboration, strong circulation is a more appropriate goal. To that end Australia's research support grants are increasingly open to non-national researchers. But there is not yet a coherent programme to support early career international experience for Australian researchers.

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

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

are increasingly used for both short and long-term research appointments. Recognition of 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.

3.1.4 Meeting the social security and supplementary pension needs of mobile researchers

Australia has a compulsory superannuation policy under which an employer must contribute to the employee's superannuation and an employee can make additional voluntary contributions. The assets in a superannuation fund remain the property of the employee and can be protected and usually can be transferred to another fund. In addition, Australia has 24 international social security agreements. These agreements help to cover gaps in social security coverage for people who migrate between countries. Responsibility for social security is shared between the countries where a person has lived between certain ages, and they may be able to receive pensions from both countries. Usually, each country will pay a part pension to a person who has lived in both countries.

3.1.5 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) was introduced in 2007 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 CTS is currently being reviewed.

There is an increasing recognition that the core generic skills of university first degree and research students is often lacking in communication, planning and organising and teamwork and preparedness for collaborative and interdisciplinary research. These issues are being considered in the research workforce strategy[20] but have not been addressed in practice.

3.2 *Research infrastructures*

Research infrastructures (RIs) are a key instrument in the creation of new knowledge and, by implication, innovation, in bringing together a wide diversity of stakeholders, helping to create a new research environment in which researchers have shared access to scientific facilities.

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

3.2.1 National Research Infrastructures roadmap

The National Collaborative Research Infrastructure Strategy (NCRIS) was a €400m, seven year strategy, 2004 to 2011, providing support for major research infrastructure. NCRIS funding is at the level of about €73m each year. In total 27 projects have been funded through NCRIS. In 2006 NCRIS developed a Roadmap[21] to guide investment. A new Strategic Roadmap for Australian Research Infrastructure, released in 2008, outlines where strategic infrastructure investments should be made over the next five to 10 years. In 2009, DIISR conducted an evaluation of the NCRIS Programme[22] to assess if the model provided an efficient, effective and appropriate mechanism for the funding of research infrastructure. The review found that, with some minor improvements, the model was appropriate. A National Research Infrastructure Council (NRIC) was formed in 2009 to provide strategic advice on future research infrastructure investments, under all infrastructure-funding programmes. In 2010 NRIC released a Discussion Paper on the Strategic Framework for Research Infrastructure Investment (DIISR, 2010e).

In addition to NCRIS there are three research infrastructure-funding mechanisms:

- The **Research Infrastructure Block Grants (RIBG)** scheme provides annual block grants to universities to meet some of the project-related infrastructure costs associated with competitive grants. RIBG expenditure in 2009-10 was €157m.
- **Sustainable Research Excellence (SRE)** augments RIBG and aims to meet some of the indirect costs of research including support staff, facilities, equipment and maintenance. These costs are not met by Australian competitive grants, which support only the direct costs of research projects. For the three years 2009-10 to 2012-13 €390m has been committed to SRE funding.

In 2007 the Government established the Higher Education Endowment Fund (later subsumed into the **Education Investment Fund (EIF)**, by allocating €2.9b from a national budget surplus. The EIF supports major new research and education infrastructure investments in universities. It is jointly administered by the Department of Education, Employment and Workplace Relations (DEEWR) and DIISR and has an independent advisory board. The EIF has distributed funds through three competitive funding rounds. The third (2010) round, with total funding of €400m included ten research infrastructure grants.

3.3 *Strengthening research institutions*

This section gives an overview of the main features of the national higher education system, assessing its research performance, the level of academic autonomy achieved so far, dominant governing and funding models.

3.3.1 Quality of National Higher Education System

There are 37 public sector universities (Universities Australia), two private universities, and two Australian branches of overseas universities. The majority of research income and publications are from the older research-intensive universities. Growing competition within the universities has led to the emergence of a number of groupings to better represent their common interests. These include the Group of

[21] http://ncris.innovation.gov.au/Documents/2006_Roadmap.pdf
[22] http://ncris.innovation.gov.au/Pages/default.aspx

Eight (Go8 -the larger universities), Australian Technology Network of Universities (ATN), Innovative Research Universities Australia, and New Generation Universities.

Education exports (largely overseas undergraduate and postgraduate students enrolling in universities) increased to €1.6b in 2008, making education the largest service export, ahead of tourism, and the third largest export industry, directly behind coal and iron ore. For the last decade education exports have been growing by an annual average of 15.7 %, compared to 10.8 % for total exports.

Publications per researcher (in all sectors) at 414 in 2008 placed Australia at the 9th place in the OECD. Citations per publication, 5.31 over the 2004-08 period, ranked Australia as 16th in the OECD (Bradley, 2008 and DIISR, 2010f).

Research Performance

There are three Australian universities in the Shanghai top 100 Higher Education index: Australian National University (59), Melbourne University (62) and Sydney University (92). 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. The first comprehensive assessment of research performance through the Excellence in Research Australia (ERA) process was completed in 2010. The report of the overall assessments (ARC, 2011) provides performance indicators for each discipline area in each university. Further information on research performance is provided in Section 2.4.1 and 2.4.2

3.3.2 Academic autonomy

Universities are autonomous in terms of governance and management (including recruitment) but have extensive and increasing reporting requirements. Most universities were established under charters from the State governments and representatives of those governments are usually appointed to the university Council. Most universities appoint independent members of the professions and representatives of the community to their governing bodies. University Vice-Chancellors have become increasingly powerful in shaping the priorities and development of universities, including the appointment of Deans. The appointment of Vice Chancellors is the responsibility of the university Council. Appointment of senior academics is usually through a committee process, including senior university managers, and not through election by peers. The 'offices' of many Vice Chancellors, i.e. the overall executive level, have grown with the appointment of Deputy Vice-Chancellors and Pro-Vice Chancellors and the growth of administrative, reporting and research support functions.

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 will in future encourage universities to concentrate funding in areas that are or might achieve high performance ranking through the ERA. Universities are not free, at this stage, to set fees for students – although some deregulation is being considered.

3.3.3 Academic funding

Direct Commonwealth government funding for universities comprises performance-based block grants and project-based competitive funding. 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. Block grants to the universities are based on assessments of performance in gaining funding through the competitive funding mechanisms. Total funding through block grants in 2010-11 was €736m, less than half of the total support for R&D in universities. The components of the block grants include RIBG and SRE (discussed in Section 3.2.1, above) and new component, the **Joint Research Engagement** (JRE) scheme (based on research income (60%), research publications (10%), and HDR student load (30%)) is now aimed at building greater collaboration between universities and the business and non-government sectors - this is a significant re-orientation from the previous scheme.

Performance-based block funding also applies to grants to support training for students undertaking Doctorate and Masters degrees by research. Schemes include the Research Training Scheme, the Commercialisation Training Scheme, the Australian Postgraduate Awards and the International Postgraduate Research Scholarships - see Section 2.2.3 above.

The distribution of block funding will change in 2012 when the performance component of the Sustainable Research Excellence (SRE) Programme is implemented. The total allocation of funds for research infrastructure under the fund was €161m in 2010-11.

As the competitive funding schemes have met only the direct costs of research, research based on competitive funding has increasingly driven the allocation of resources derived from block grants. The new SRE, based on research performance by discipline, will strongly shape organisation-level allocation decision. In addition the government is also currently negotiating longer-term the 'mission-based compacts' with each university, and these will include agreement on a research strategy.

3.4 *Knowledge transfer*

This section will assess the national policy efforts aimed to promote the national and trans-national public-private knowledge transfer.

3.4.1 Intellectual Property Policies

All Australian PROs and universities have explicit and published IP policies. Those policies 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 2005-7, the average number of commercialisation staff per university is 7 to 8 (or 4.1 across all research organisations - comparable to the US and Canada, but significantly less than the UK). Average expenditure per university is about €7m. 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.

Two reports have been produced to guide the management of commercialisation, one funded by government (DEST, 2002) and one funded by the Business Council of Australia in 2004 (BCA, 2004).

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

Spin-offs

Spin-off activity across the non-business research sector is about 1 spin-off per €73m of research expenditure or about 28 across the university sector. This level is similar to the US and Canada, but significantly less than the UK (DIISR, 2009c).

When Commercialisation Australia was formed 2009 it replaced a range of previous schemes[23]. Commercialisation Australia is now the primary source of Australian Government assistance for commercialisation and provides support linked to the key commercialisation development stages. Commercialisation Australia has funding of €178m for the 5 years to 2014, with ongoing funding of €60m per year thereafter. Its programmes provide grants for commercialisation and its support includes assistance to entrepreneurs by mentors and service providers.

The Commonwealth government has conducted five comprehensive surveys of the direct commercialisation performance of PROs and universities, published as the National Surveys of Research Commercialisation, for example in DIISR (2009c).

The Australian Institute for Commercialisation is an independent body, established with substantial government funding, which aims to contribute to commercialisation of public sector knowledge and to improved research-business links.

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. This is because the salaries in the university sector are usually low relative to those in business and also because work in business is much less likely to enable the researcher to generate the publications track record increasingly essential for entry and advancement in the university sector. Superannuation has become increasingly flexible is no longer a major barrier (Hugo, G. & Morriss, A., 2010; Hugo, G., 2007).

Promoting research institutions - SME interactions

The 2006 Innovation in Australian Business survey (ABS, 2008) estimated that over 2004-6, 3.1% of SMEs collaborated for innovation with HEIs (13th in the OECD) and 2.9% with PROs (9th in the OECD) (DIISR, 2010a). In view of the high proportion of

---

23 http://www.innovation.gov.au/AboutUs/KeyPublications/PortfolioFactSheets/Documents/COMMERCIALISATION-AUSTRALIA.pdf

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 (see Section 2.5.1).
- Researchers in Business (RiB), a component of the Enterprise Connect Programme covers half of the salary of a researcher from a PRO or HEI working in a firm for up to 12 months.
- Collaboration with SMEs is an element of the 'compacts' being negotiated between universities and the government funding bodies (see Section 2.2.3).

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.

Regional development policy

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 of the 'compacts' currently being negotiated between universities and the government funding bodies (see Section 2.2.3) and in the Joint Research Engagement (JRE) funding which aims at building greater collaboration between universities and the business and non-government sectors.

3.5 *Cooperation, coordination and opening up national research programmes with the EU*

This section assesses the effectiveness of national policy efforts aiming to improve the coordination of policies and policy instruments across the EU.

3.5.1 National participation in intergovernmental organisations and schemes

The articulation between the R&D Framework Programmes, the Structural Funds and the Competitiveness and Innovation Programme is still underdeveloped in terms of coordination, synergies, efficiency and simplification. The policy fragmentation at EU and national level, and between EU and national policies can hinder the build of critical masses of research excellence, leads to the duplication of efforts, sub-optimal impacts of the different instruments and unnecessary administrative overheads. Differences between research selection procedures and criteria can also be an obstacle to the overall spread of excellence. This section assesses the effectiveness of national policy efforts aiming to improve the coordination of policies and policy instruments across the EU, all part of the drive to create an integrated ERA.

While international linkages and collaboration have become increasingly important for Australian research, the government has an explicit objective of increasing international collaboration in research.

Recent changes in some funding programmes have significantly increased the scope for international collaboration. For example, changes have been made to the ARC's Discovery Projects, Linkage Projects and other national competitive grants schemes to facilitate international collaboration. In the Discovery Projects, overseas-based partner investigators will be eligible for funding for travel to Australia, and International Collaboration Awards have been introduced to enable chief investigators, fellows and overseas-based partner investigators to travel for the purpose of collaborative research. 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 – see also Section 2.5.2.

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[24] and in the continuing joint support for The Forum for European–Australian Science and Technology Cooperation (FEAST) - an organisation established by the Australian Government and the European Union to promote and facilitate research collaboration.

Framework Programme

The level of Australian participation in the Framework Programmes has grown from FP4 in 1994-8:

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

By July 2010, Australian researchers were participating in 74 FP7 projects with total funding of €379m across a wide range of thematic areas and topics (Table 7)[25]).

Table 9. FP7 Australian participation in the 7th Framework Programme

Thematic Area	Number of Projects	Total funding (€ million)
Health	12	94
Biotech, Food, Agriculture and Fisheries	11	61
Information & Communications Technologies	15	57
Nanotechnologies, Materials & Production Technology	5	18
Energy	3	12
Environment	7	57
Science in Society (SIS)	3	3
Mobility (Marie Curie Actions)	13	3
Research Infrastructures	5	74
TOTAL	**74**	**379**

Source: FEAST, 2010. Note: Contracts signed by July 2010).

The best available data indicate that approximately €5m have flowed from the EU to Australia during its participation in FP4, FP5 and FP6. A comparable sum has been

24 http://www.foreignminister.gov.au/releases/2008/fa-s163_eu_aust_partnership.html
25 http://www.innovation.gov.au/Science/Documents/AustraliaEUJSTCCRoadmap.rtf

provided by Australian research funders to Europeans to engage in collaborative research. FEAST conducted a stock take of Australian engagement in FP7, in 2010. According to this study, from the beginning of FP7 (December 2006 to May 2008), Australian organisations participated in 112 collaborative projects. The majority of applications with Australian involvement were not successful. Most successful applications were in ICT, Health and Knowledge-Based Bio-Economy (KBBE) -the overall success rate of the sample was 33%, ranging from 0% to 75% (in KBBE). The stock-take covered 59 projects and found that on average the Australian researchers committed €210k of their own resources (in-kind contributions and/or existing funds) and had access to €220k in additional domestic funding.

COST

There have been 85 instances of Australian institutions participating in COST actions since 2005. COST has also invited and funded 120 Australian researchers to participate in COST Action meetings over the period from 2005 to 2010 (Australia–European Union JSTCC, 2010)

3.5.2 Bi- and multilateral RDI agreements with EU countries

Comprehensive information on Australia's international research engagement is not available. However, the participation of international collaborators in ARC funded research projects provides an indicative perspective. Of projects with international collaborators in 2009, 45% were with Europe, 30% with North America and 18% with Asia. International collaboration, as indicated by joint authorship of publications, has been accelerating since the early 1990s, with collaboration with Europe growing most rapidly. A recent bibliometric study found that the proportion of Australian publications in the Science Citation Index with international co-authorship increased from 21% in 1991 to 44% in 2005 and is growing at almost double the rate of purely domestic papers. In 2005 about 5,000 scientific papers were co-authored between Australian and European authors, and about 3,500 with US authors. Over the 1991-2005 period the leading fields of collaboration, based on joint authorship, were, in order: Health and medical science; biological science; physical science; engineering and technology; and earth sciences (Matthews, et al, 2009). A recent report provides an overall review of the aims and management of Australia's international science and technology collaboration, but not data on its structure (House of Representatives, Standing Committee on Industry, Science and Innovation, 2010).

Collaboration with the EU - 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 JSTCC met in June 2010 and Australia and the European Union agreed on a Science and Technology Cooperation Roadmap for 2010-2012.

The Australia-Europe Research Collaboration Fund (Europe Fund)[26] is the key vehicle for the Australian Government research links with the European Union, and with European countries. The Fund also provides support for the Forum for European-Australian Science and Technology cooperation (FEAST). Researcher mobility is supported via Australian participation in the European Commission's International Research Staff Exchange Scheme. Under this scheme the Australian Academy of Science provides a contribution towards the costs for Australian research

[26] https://grants.innovation.gov.au/IAP/Pages/Doc.aspx?name=AustraliaEuropeFund.htm

organisations to establish or reinforce long-term research co-operation through short-term institutional staff exchanges.

Collaboration with European Countries - DIISR supports S&T collaboration with a number of countries in Europe including: Germany, France and the United Kingdom.

Collaboration with other countries – With regard to collaboration with many Asian countries a government-to-government framework is often essential for counterparts to obtain support, and to 'kick start' collaboration where there is limited history of links.

- **Collaboration with China**- *Collaboration with China*[27] is important for Australia for a number of reasons, most importantly 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. This relationship has been recognised by the establishment in 2001 of the Australia-China Special Fund for S&T. The programme is now in its 9th round and each country provides about €1.5m per annum to support collaborative research.
- **Collaboration with India** - the Australia-India Strategic Research Fund (AISRF) established in 2006 provides a framework of collaboration.
- 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.
- Collaboration with the **Asia-Pacific** – Australia has a range of S&T collaboration arrangements with other countries of the Asia-Pacific region. One of the most important bilateral S&T collaborations is with Korea, through the International Science Linkages (ISL) Programme.

3.5.3 Other instruments of cooperation and coordination between national R&D programmes

While there is participation in conferences organised under various EU initiatives, neither the Australia–European Union S&T Cooperation Roadmap 2010-2012 - Research and Innovation Priorities, nor the FEAST Stocktake of Australian-European collaboration under FP7, identify any links under the ESF, the ETF, the JTI or the Joint Programming Initiatives. No Australian organisations participate in ERA-NETs.

3.5.4 Opening up of national R&D programmes

Australia aims to attract high performing researchers from all countries and has recently significantly expanded the funding and the eligibility for a range of research grants, including:

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. In addition to salary

---

27 http://www.innovation.gov.au/Science/InternationalCollaboration/Pages/CollaborationwithChina.aspx

support, each researcher's administering organisation will receive funding to support related infrastructure, equipment, travel and relocation costs.

- The *Australian Laureate Fellowships* scheme administered by the ARC and the *Australia Fellowships* scheme administered by the NHMRC aims to attract more senior international and Australian researchers. *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 per year is provided.
- The Endeavour Research Fellowships, administered by DEEWR, 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.
- International Postgraduate Research Scholarships (IPRS) – the Commonwealth Government provides about €14.5m per annum 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 Australian research. Scholarships are open to international students.

As discussed in Section 2.5.2., 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[28].

3.6 *International science and technology cooperation*

3.6.1 International cooperation (beyond EU)

The Australian Academy of Science commented in 2010 in relation to Australia's international S&T cooperation: *"What is still lacking… is an integrated national strategy that focuses and supports international science efforts across Australian Government departments and agencies to ensure continuity in strategic scientific relationships, and provide a competitive basis for Australia's international long-term scientific engagement in the 21st century"* (Australian Academy of Science, 2010).

This report, and Commonwealth Parliament, House of Representatives (2010), consider that the government approach to international S&T collaboration lacks a strategic framework, effective mechanisms and adequate funding. The overall approach is not informed by a strategic assessment of opportunities, threats and priorities, is not proactive, and does not promote engagement with Australian and international industry to maximise links between academic and industrial research and innovation.

Both reports recommend the expansion of Australia's science and technology Counsellor network and closer coordination of these Counsellors in a national office of international S&T cooperation (see Section 3.5.2 for further information on the framework for collaboration with the EU and other countries).

---

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

3.6.2 Mobility schemes for researchers from third countries

The report of the Australian House of Representatives Standing Committee on Industry, Science and Innovation (2010) on international research collaboration, this committee's earlier report on the research workforce (Australian House of Representatives Standing Committee on Industry, Science and Innovation, 2008), and the work in 2010 and 2011 on developing a research workforce strategy, identify the importance of greater mobility of researchers, including those from third countries. The Australian House of Representatives Standing Committee on Industry, Science and Innovation (2010) in particular identifies delays in obtaining visas, or rejection of visas, as a significant impediment faced by universities and research organisations in recruiting third country researchers for long or short term appointments.

4 CONCLUSIONS

4.1 *Effectiveness of the knowledge triangle*

While economic growth is robust, due largely to minerals exports, enabling sustained public investment in research, productivity growth has slowed. 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. 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. The Innovation, Industry, Science and Research portfolio 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 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, is planned and aims to more effectively assist smaller and fast growth firms. The future trend in BERD is uncertain due to a combination of factors - structural change due to growth of resource exports and the rising exchange rate, competition for human resources, and the challenge of growing services exports into emerging markets.

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 new research performance assessment framework will focus funding on high performing research teams.

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. 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.

Table10: Effectiveness of knowledge triangle policies

	Recent policy changes	**Assessment of strengths and weaknesses**
Research policy	Introduction of the Excellence in Research for Australia (ERA) initiative linked to the	+Increase in funding for research and infrastructure.

	Sustainable Research Excellence (SRE) to drive investment into high performing research groups. Development of a Strategic Roadmap for Research Infrastructure investment linked to substantial increases in funding for infrastructure. The proposed shift from and R&D tax deduction to an R&D tax credit aims to better support small high growth firms and to also encourage overseas investment into R&D in Australia. Almost all government funded research programmes have been significantly opened to greater participation by overseas researchers, and most high level fellowships are fully open. A comprehensive research workforce strategy is under development. The development of 'compacts' or agreements over strategic priorities across research, teaching and engagement with each university.	+More strategic approaches to assessment, priorities and human resource development. -Lack of an effective approach to building closer collaboration with users, -Lack of a strategic approach to international research collaboration. -Mobility of researchers between industry and university limited by incentive structures -Impediments to the inflow of international researchers from delays or restrictions on visas.
Innovation policy	The most significant changes have been: The National Enabling Technologies Strategy, including the development of fore-sighting. The formation of Commercialisation Australia. The further development of Enterprise Connect to support capability development in SMEs. The substantial increase in funding for the Clean Energy Initiatives in the context of strategies to support pilot plants to apply research.	+'Systems' approach, with the significant developments in strategy for the enabling technologies. -Lack of effective approach to strengthening linkages in the innovation system. –mismatch in fields of research in universities and in business. -Lack of a mechanism to build and support research - industry collaboration in applied research. -Growth of the resources sector significantly based on exports to China continues to drive structural change. -A level of complacency regarding the development of new bases of competitiveness.
Education policy	The policy changes following the Bradley Review of Higher Education have increased funding to universities and reduced regulation over student fees. The substantial increase in funding into the Education Investment Fund (now over €8b) will support investment in research and teaching infrastructure.	+Goals of increasing participation in tertiary education. -Long term decline in the level of government support per student, -universities highly dependent overseas students. -Universities face demanding 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

	Initiatives to increase enrolments in SET courses.	junior staff may lead to poor recruitment. -Low enrolments by domestic students in PhD courses in SET remain a problem.
Other policies	The eligibility of foreign students and researchers to scholarships, fellowships and research project funding has been widened.	-Approaches to international research collaboration remain un-strategic, poorly funded and little evaluated.

4.2 *Comparison with ERA 2020 objectives - a summary*

Due to the range of recent reviews and initiatives, the policy context is dynamic and the impact of new measures uncertain. Investment in research and research infrastructure has grown strongly since 2008. More recently, evaluation of research quality is being used to focus support on high performing groups. There are many mechanisms to support consultation and coordination in the research and innovation system, but little in the way of a strategic framework.

There is a clear recognition of the growing importance of collaboration in research and innovation. The relatively low levels of domestic collaboration in innovation are seen as a problem, but to date few initiatives have effectively addressed this area. International research collaboration is growing strongly, including with emerging Asian countries. The mechanisms to support such collaboration, both through inter-governmental schemes and through changes in research funding at the project and programme level, are being progressively developed. Immigration is an important source of research personnel, and with the ageing of the research workforce and the mobility of Australian researchers is becoming more important.

Table 11: Assessment of the national policies/measures which correspond to ERA objectives

	ERA objectives	**Main policy changes**	**Assessment of strengths and weaknesses**
1	Ensure an adequate supply of human resources for research and an open, attractive and competitive labour market for male and female researchers	An extensive review of research workforce supply and demand has been completed. A research workforce strategy released in 2011. 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 study not strongly attractive to Australian nationals;
2	Increase public support for research	Substantial (25%) increase in government funding of research from 2008-9.	+ Strong government budget -Lack of strategic focus
3	Increase coordination and integration of research funding	Coordination mechanisms at the federal inter-governmental (inter-ministerial and inter-departmental levels. Explicit but broad national research priorities.	+Primary reliance on bottom-up investigator led research. -Lack of coherent strategic framework.
4	Enhance research capacity	Systematic approach to research workforce development; Strong investment in research infrastructure;	-Little focus on developing research capability in industry.

	ERA objectives	Main policy changes	Assessment of strengths and weaknesses
		Some targeted investment in IT, biotech and other 'enabling technologies'.	
5	Develop world-class research infrastructures (including e-infrastructures) and ensure access to them	Development of an infrastructure development roadmap; Development of substantial funds for infrastructure; Approach to funding emphasises openness; Additional new infrastructure funding programme emphasises relevance to industry.	+Sustained funding; +Emphasis on shared facilities.
6	Strengthen research institutions, including notably universities	Systematic research evaluation (ERA); Linking research performance to core funding (SRI)'; Negotiation of performance 'compacts' with universities.	+Increased funding for research and infrastructure; +Clear performance criteria. -Base funding of universities' teaching functions remains inadequate; -Few incentives for collaboration with industry.
7	Improve framework conditions for private investment in R&D	Long standing R&D tax concession; Proposed new tax credit scheme; Wider eligibility of MNC research.	+Reasonable clarity due to a long standing entitlement scheme; +Greater incentive for new ventures (in the tax credit scheme). -Level of incentive has declined with declining corporate tax rates; -Uncertainty as future policy remains unclear.
8	Promote public-private cooperation and knowledge transfer	Mechanisms include the Cooperative Research Centres Programme (CRC); ARC Linkage Programme and the Rural Research and Development Corporations (RDCs) and the CSIRO Flagship Programme.	+Stable programmes. -Lack of a flexible bilateral collaborative applied research mechanism; -Lack of a strategic orientation to industry collaboration.
9	Enhance knowledge circulation	Opening of university research funding to non-nationals. Development of international research links	+Review of international links programme +Increasing researcher mobility +Extensive formal and informal international collaboration. +Substantial role of foreign-owned firms -Remote location
10	Strengthen international cooperation in science and technology	Increasing range of international research collaboration arrangements (eg with China and India); Increase in dedicated funding; Increase in strategic orientation to collaboration.	-Little assessment of the evolution and outcomes of collaboration; -Limited industry participation in collaboration.
11	Jointly design and coordinate	Well developed consultative and	-Lack of systematic

	ERA objectives	Main policy changes	Assessment of strengths and weaknesses
	policies across policy levels and policy areas, notably within the knowledge triangle.	coordination mechanisms and approaches	collaboration development mechanisms
12	Develop and sustain excellence and overall quality of research.	Systematic research quality evaluation (ERA);	+Sustained funding for research
13	Promote structural change and specialisation towards a more knowledge - intensive economy	Initiative to develop a national enabling technologies strategy.	+ Increasing focus on education and skills in all areas.
14	Mobilise research to address major societal challenges and contribute to sustainable development.	Strong increase in funding for 'Clean Tech'; Greater funding for environmental research.	-Poor linkages between research and market formation and commercialisation.
15	Build mutual trust between science and society and strengthen scientific evidence for policy making	New Science Awareness Strategy	+Good capacities and open channels for scientific evidence to contribute to policy.

References

ABS (2006) Innovation in Australian Business, 2005. Cat. No. 8158.0

ABS (2007a) Research and Experimental Development, Higher Education Organisations, 2006, Cat. No. 8111.0.

ABS (2007b) Australian Social Trends, 2007, 2006, Cat. No. 4102.0.

ABS (2008a), Innovation in Australian Business, 2006-07, Cat. No. 8158.0

ABS (2008b), Research and Experimental Development, All Sector Summary, Australia, 2006–07, Cat. No. 8112.0

ABS (2008c), Research and Experimental Development, Government and Private Non-Profit Organisations, Australia 2008 Cat. No. 8109.0.

ABS (2009a), Research and Experimental Development, Businesses, Australia, 2007-08, Cat. No. 8104.0

ABS (2009b), Selected Characteristics of Australian Businesses, 2007-08, Cat. No. 8167.0.

ABS (2009c), Summary of IT Use and Innovation in Australian Business, 2007-08. Cat. No.. 8166.0

ABS (2010a) Research and Experimental Development, Higher Education Organisation, Australia, 2008-09. Cat. No. 8111.0.

ABS (2010b), Research and Experimental Development, All Sector Summary, Australia, 2008-09. Cat. No. 8112.0

ABS (2010c), Research and Experimental Development, Business, 2008-9. Cat. No. 8104.0

ABS (2010d), Venture Capital & Later Stage Private Equity Survey, 2008-9, Cat. No. 5678.0

ABS 2010e) Innovation in Australian Business, 2008-09. Cat. No. 8158.0

Access Economics (2010), Australia's Future Research Workforce: Supply, Demand and Influence Factors. Report for the Department of Innovation, Industry, Science and Research.

Ainley, J, Kos, J. and Nicholas, M. (2008) Participation in Science, Mathematics and Technology in Australian Education. Australian Council for Educational Research (ACER) Research Monograph No 63

ARC (2009), ARC-supported research: the impact of journal publication output 2001–5, report prepared by the Research Evaluation and Policy Project, ANU.

ARC (2011) ERA 2010 National Report. Australian Research Council. Canberra.

Australia-European Union (EU) Joint Science and Technology Cooperation Committee (2010) Australia – European Union S&T Cooperation Roadmap 2010-2012 Research and Innovation Priorities. Canberra.

Australian Academy of Science (2009) Internationalisation of Australian Science – Position Paper. Australian Academy of Science Internationalisation of Australian Science, Canberra.

Australian National Audit Office (2009) Innovation in the Public Sector: Enabling Better Performance, Driving New Directions. Commonwealth of Australia

BCA (2004) New Model for Best Practice Commercialisation Policy Business Council of Australia. Melbourne.

Bell, S., Women in Science and Technology in Australia: Maximising Productivity, Diversity and Innovation (Canberra: FASTS, 2009).

Birrell, B., Rapson, V., Dobson, I. R., & Smith, T. F. (2004). Skilled Movement in the New Century: Outcomes for Australia. Centre for Population and Research, Monash University.

Bradley, D. (2008) Review of Australian Higher Education Final Report. Commonwealth of Australia. Canberra

Chan, E. (2005) '*Entrepreneurship Education In Australia- A Preliminary Study. 'Journal of As*ia Entrepreneurship and Sustainability.Vol 1. No. 2

Coates, H. *et al.*, (2009), The Attractiveness of the Academic Profession: A Comparative Analysis. Research Briefing. Available at: http://works.bepress.com/hamish_coates/46.

Commonwealth of Australia (2001) Backing Australia's Ability - An Innovation Action Plan for the Future. Commonwealth of Australia. Canberra

Commonwealth of Australia (2009) Powering Ideas: An Innovation Agenda for the 21st Century. Commonwealth of Australia, Canberra.

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

Commonwealth Parliament, House of Representatives Committee on Industry, Science and Innovation (2010). Australia's International Research Collaboration. Canberra

Commonwealth Parliament, Senate Economics Committee (2008) Lost in Space? Setting a new direction for Australia's space science and industry sector Canberra [http://www.aph.gov.au/Senate/committee/economics_ctte/space_08/index.htm]

Commonwealth Parliament, Senate Economics Committee (2010) Tax Laws Amendment (Research and Development) Bill 2010 and Income Tax Rates Amendment (Research and Development) Bill 2010. Canberra

Cutler, T (2008), Venturous Australia. Review of the National Innovation System, Cutler & Company Pty Ltd, Melbourne;

Department of Education, Science and Training (2007), National Survey of Research Commercialisation 2005-07. DEST, Canberra.

Department of Education, Science and Training (DEST) (2006). Audit of Science, Engineering & Technology Skills. Commonwealth of Australia.

Department of Finance (2010) The Government and Industry Principles of Engagement on ICT. Canberra. http://www.finance.gov.au/procurement/ict-procurement/government_and_industry_principles_of_engagement_on_ICT.html

Department of Finance and Deregulation (2008) *Commonwealth Procurement Guidelines*, Financial Management Guidance No. 1. Canberra,

Department of Foreign Affairs and Trade (2009), Composition of Trade Australia 2008-09, DFAT, Canberra,

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

Department of Prime Minister and Cabinet (2010) Ahead of the Game: Blueprint for the reform of Australian Government Administration. Canberra

DEST (2002) Employability Skills for the Future. Department of Education, Science and Training. Canberra.

DEST (2005) Salary Relativities and the Academic Labour Market. DEEWR. Canberra

DIISR (2009a) Framework of Principles for Innovation Initiatives. Canberra.

DIISR (2009b) Supporting Australia's research workforce: Snapshot of government research workforce programs – 2009/10. Canberra.

DIISR (2009c) National Survey of Research Commercialisation: 2005-2007. Department of Innovation, Industry, Science and Research.

DIISR (2009d), The Australian Government's 2009-10 Science and Innovation Budget Tables

DIISR (2010a) The Australian Government's 2010-11 Science, Research and Innovation Budget Tables. Canberra.

DIISR (2010b) Innovation Metrics Framework Project -Consolidated Report. DIISR Canberra.

DIISR (2010c) Meeting Australia's research workforce needs. *A consultation paper to inform the development of the Australian Government's research workforce strategy*. Department of Innovation, Industry, Science and Research. Canberra.

DIISR (2010d) National Collaborative Research Infrastructure Strategy (NCRIS) Evaluation Report. DIISR, Canberra.

DIISR (2010e) Strategic Roadmap for Australian Research Infrastructure Discussion Paper, Canberra

DIISR (2010f) Australian Innovation System Report, 2010. Commonwealth of Australia 2010.

DIISR (2010g) National Enabling Technologies Strategy. Canberra.

Edwards, M (2001) University Governance: a mapping of some issues. Lifelong Learning Network.

Engineers Australia (2002) The *Engineering Profession: A Statistical Overview, IEAust, Canberra.*

Engineers Australia (2005) The *Engineering Profession: A Statistical Overview, IEAust, Canberra.*

European Commission, Joint Research Centre, Institute for Prospective Technological Studies (2009). 2009 EU Industrial R&D Investment Scoreboard. European Commission Brussels. [http://ftp.jrc.es/EURdoc/JRC54920.pdf]

Forum for European-Australian Science and Technology Cooperation (2010) Stock take of Australian engagement with FP7. FEAST Discussion Paper May 2010. FEAST, Canberra.

Gershon, P. (2008) Review of the Australian Government's Use of Information and Communication Technology. Department of Finance. Canberra.

Government of Queensland (2008) Queensland research and development investment strategy 2010-2020. Brisbane [

Government of Queensland (2008), Smart Queensland: Smart State Strategy 2008-2010.

Government of Victoria (2008) Innovation: Victoria's Future, The Victorian Innovation Statement. Melbourne

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

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

Haukka, S. (2005) Research training and national innovation systems :Finland compared to Australia and the USA. Technical Report National Technology Agency of Finland, Helsinki

House of Representatives, Standing Committee on Education and Training, (2009) Inquiry into combining school and work: supporting successful youth transitions. Australian Parliament.

Hugo, G. & Morriss, A. (2010) Investigating the Ageing Academic Workforce: Stocktake. The National Centre for Social Applications of Geographic Information Systems, The University of Adelaide, and Anama Morriss Consulting & Associates.

Hugo, G. (2008) Issues and Options For Enhancing The International Mobility Of Researchers. OECD Committee for Scientific and Technological Policy (CSTP) and Steering and Funding of Research Institutions (SFRI) Workshop on *The International Mobility of Researchers*, IEA Paris, 28 March 2007

Hugo, G. (2008), Issues and Options for Enhancing the International Mobility of Researchers: An Australian Perspective, Paper prepared for OECD Committee for Scientific and Technological Policy and Steering and Funding of Research Institutions workshop on the International Mobility of Researchers, IEA, Paris, 28 March 2007.

Karmel, T. (2004) Australia.s approach to lifelong learning. National Centre For Vocational Education Research

Matthews, M. et al (2009) A Bibliometric Analysis of Australia's International Research Collaboration in Science and Technology*. FEAST Discussion Paper 1/09.*

Melbourne Institute (2009) The IBM® – Melbourne Institute Innovation Index of Australian Industry. Melbourne Institute of Applied Economic and Social Research, The University of Melbourne. Melbourne.

Melbourne Institute (2009), R & D and Intellectual Property Scoreboard 2008. Melbourne Institute of Applied Economic and Social Research, The University of Melbourne. Melbourne.

O'Kane, M. (2008) Collaborating for a Purpose. Review of the CRC Program. Department of Innovation, Industry, Science and Research. Canberra.

OECD (2008a) Learning for Jobs OECD Reviews of Vocational Education and Training – Australia. Paris.

OECD (2008b), The Global Competition for Talent: Mobility of the Highly Skilled (Paris: OECD,).

OECD (2008c), Eco-Innovation Policies in Australia*,* Environment Directorate, OECD. Paris

Palangkaraya, A. Stierwald, A. Webster, E. and Jensen, P. (2010) Examining the Characteristics of Innovative Firms in Australia. A Report for the Australian Government Department of Innovation, Industry, Science and Research. Melbourne Institute of Applied Economic and Social Research, The University of Melbourne. Melbourne.

PMSEIC (2006) Australia's Science and Technology Priorities for Global Engagement, a report of the PMSEIC working group, Prime Minister's Science, Engineering and Innovation Council. Canberra.

Precision Consulting (2007).Graduate Employability Skills Prepared for the Business, Industry and Higher Education Collaboration Council. Department of Education, Science and Training. Canberra.

Productivity Commission (2007), Public Support for Science and Innovation, Productivity Commission, Canberra,

Rigby, B. (2009) Review of Graduate Skills- Critical thinking, team work, ethical practice and sustainability. Australian Learning and Teaching Council, Department of Education, Employment and Workplace Relations.. Canberra.

Roos, G, Fernstrom, Land Gupta, O (2005), National innovation systems: Finland, Sweden & Australia compared, Learnings for Australia, Australian Business Foundation, November 2005.

Sanyal, K. (2009) Australia's foreign investment relationship with partner countries. Parliament of Australia Department of Parliamentary Services Parliamentary Library, Canberra.

Skills Australia (2010) Creating a future direction for Australian vocational education and training. A discussion paper on the future of the VET System. Canberra, October 2010

Swansson, J. Mow, K. and Bartos, S. (2005). Good university governance in Australia" Proceedings of 2005 Forum of the Australasian Association for Institutional Research.

The Allen Consulting Group (2010) Researchers in Australia. Report to the Department of Innovation, Industry, Science and Research. Canberra.

Thomson Reuters (2010), Global Research Report: Australia and New Zealand. Melbourne.

Trewin, D (2004) Beyond the Brain Drain – Statistical Notes. In Wood (2004)

UNCTAD (2005), World Investment Report. Transnational Corporations and the Internationalization of R&*D*, United Nations Conference on Trade and Development New York and Geneva, 2005.

Universities Australia, International Links of Australian Universities, UA, Canberra, 2009.

West, J. (2006) A Strategy to Accelerate Innovation in NSW. Outline for Policy Development.

Wood, F. (2004) Beyond the Brain Drain: Mobillity, Competitiveness and Scientific Excellence. FASTS. Canberra.

List of Abbreviations

AIMS	Australian Institute of Marine Science
ANSTO	Australian Nuclear Science and Technology Organisation
ANU	Australian National University
ARC	Australian Research Council
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 Committee
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSTACI	Commonwealth, States and Territories Advisory Council on Innovation
DIISR	Department of Innovation, Industry, Science and Research
DSTO	Defence Science and Technology Organisation
ERA	European Research Area
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
FEAST	Forum for European-Australian Science and Technology cooperation
FP	European Framework Programme for Research and Technology Development
FP	Framework Programme
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
HEI	Higher education institutions

HERD	Higher Education Expenditure on R&D
HES	Higher education sector
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
PRO	Public Research Organisations
R&D	Research and development
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
S&T	Science and technology
SF	Structural Funds
SF	Structural Funds
SME	Small and Medium Sized Enterprise
UA	Universities Australia
VC	Venture Capital