Australia's Innovation Future

A Report on the Structure and Performance of Australia's National Innovation System

ABSTRACT

This Report addresses the Terms of Reference of the Senate Economics References Committee inquiry into the Australian Innovation System. The Report recommends that Government should take action, in collaboration with research organisations and business, to lift innovation performance in five Strategic Action Areas: leadership and policy direction; building enterprise capability; lifting investment in science and research; supporting local innovation ecosystems; and addressing skills formation through an integrated tertiary education system.

Summary

Science, research and innovation are central to securing Australia's future. For too long Australia has relied on the commodity cycle to underwrite its prosperity. Australia must become a 'smart' nation, drawing on knowledge and ideas to build competitive and sustainable businesses that create high skill, high productivity jobs and that capture value through integration into the global economic system.

The Government's most recent *Australian Innovation System Report* finds that Australia ranks highly for public research and innovation inputs, but lags in 'innovation efficiency', which is a measure of our ability to translate research into commercial outcomes. This makes us increasingly vulnerable to global shocks. Australia runs last in the OECD for research-business collaboration, and our relative performance in STEM education is in decline.

Aim of report

This Report was prepared to support a Senate inquiry into Australia's innovation system. The Report analyses our national innovation system and identifies factors that would contribute to Australia becoming a high performing knowledge-based economy in an interconnected world of design, creativity and accelerating technology-driven change. Future economic growth and commitments to social inclusion and environmental sustainability are closely bound up with our capacity for innovation.

Government can lead and invest in science and innovation but it cannot substitute for the innovators. Today the most transformative innovations are taking place at the intersection of industries, businesses and research disciplines, and a key role of public policy is to facilitate these connections. In Australia, it can build on a formidable track record in agriculture, mining and health and medical research, with notable commercialisation successes.

Innovation drivers

The Report concludes that Government should adopt an approach to science, research and innovation policy that recognises the following innovation drivers:

- More stable, coherent and effective administrative arrangements, a long-term time horizon and a budgeting and resource allocation system that is fit for purpose, with a target to lift Australian investment in R&D from the present 2.1 per cent of GDP to three per cent
- Innovation system leadership and coordination through a peak body for science, technology and innovation policy, which engages with key stakeholders to undertake policy foresights, set priorities and develop early responses to challenges and opportunities
- Strategic approach to building innovation capability in Australian businesses through improved agility and participation in global value chains, commitment to management capability building and greater collaboration with the research sector
- Long-term, predictable and secure funding to support science, research and innovation in alignment with national priorities, as well as research training, researcher mobility and national and landmark research infrastructure
- Local and regional innovation ecosystems, as a catalyst and enabler for industry development and transformation through entrepreneurial start-up activities, business and research networks and supportive policies and infrastructure
- Tertiary education institutions that are positioned to educate and train Australia's future entrepreneurs, employees and managers through greater integration of responsibilities for education outcomes between the Commonwealth and States/Territories.

Strategic Action Areas

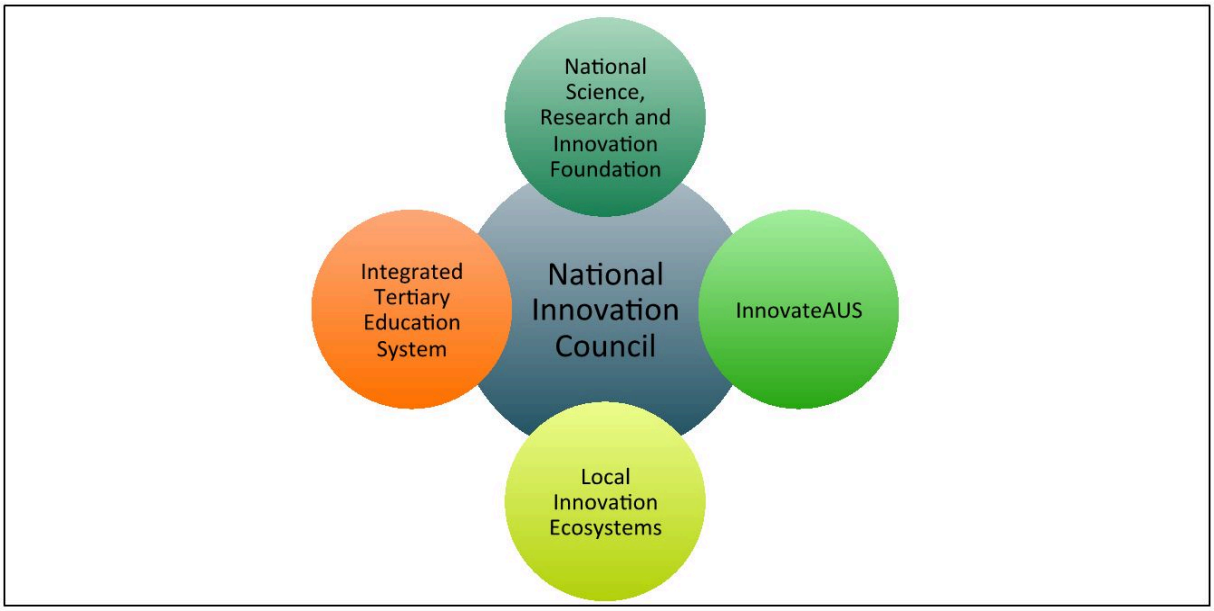
Accordingly, there are a number of actions that governments can take to improve the performance of the national innovation system in five Strategic Action Areas:

1. Establish a *National Innovation Council (NIC)* to develop and advise on national innovation policy. The NIC would undertake regular knowledge foresight exercises, set national innovation

and industry development priorities and promote active communication, cooperation and partnership across sectors and agencies. The Prime Minister would chair the Council

2. Establish an independent agency, *InnovateAUS*, to build enterprise capability and promote collaboration through a targeted programme portfolio of enterprise capability, global growth, industry clustering and public procurement. InnovateAUS would develop, implement and review policy in relation to taxation and R&D incentives and venture capital.
3. Establish a *National Science, Research and Innovation Foundation (NSRIF)* as the investor in Australian science, research and innovation. The Foundation would undertake a long term (10 year) portfolio approach to achieve a balance between research excellence, relevance and impact, and between investigator driven, mission driven and industry driven priorities
4. Implement a *Local Innovation Initiatives Investment Fund* to build and sustain capacity in entrepreneurship, collaboration and start-up company formation in high growth innovation districts and emerging entrepreneurial ecosystems. Funding would be available for collaborations between research and education institutions, businesses and start-up communities.
5. Build an integrated *National Tertiary Education System* that brings together the higher education and vocational education and training systems to prepare people for Australia's future workforce needs. The system would aim for a more effective system-wide combination of institutional and workplace learning.

Figure 1: Five Strategic Action Areas



The Report's view on the scope of these Strategic Action Areas (SAAs) is covered in Part II of the Report. Part I provides an overview of the issues behind the recommended Actions.

Introduction

The poor performance of Australia's national innovation system has been well canvassed in reports, papers and policy documents over the last seven years – beginning with *Venturous Australia*[1] and culminating in the current groundswell of opinion from business, research organisations, policy think-tanks, the media, and Members of Parliament.

Submissions to the Senate inquiry and recent public discussion have pointed to significant gaps in support for innovation, including the very low level of business investment in research and development, a potentially serious skills shortfall, particularly in STEM areas, the low level of collaboration between industry and research organisations, and limited support for growing new businesses beyond the start-up stage. A number of submissions also referred to the low level of commitment to research and support for the creative industries.

The objective of this Report is to contribute to the current policy discussions and directions in science, research, education, industry and innovation policy, drawing on the insights from a wide range of interested people and organisations who took the time to prepare submissions and give evidence to the inquiry. It builds on an earlier Interim Report and Issues Paper prepared for the inquiry[2].

A broad view of innovation

The innovation 'system' comprises the relationships between knowledge creating organisations (principally research and education bodies), knowledge adopters (industry and the businesses that constitute it) and government (in its policy, funding, market creation and regulatory roles). Financial institutions, including venture capital investors, innovation intermediaries, professional advisers and consultants all play an important financing, enabling and integrating role.

In essence, *innovation is ideas applied successfully*. This Report takes a broad view of the scope of innovation: it covers new products, services and methodologies, scientific insights and technological breakthroughs, new perceptions in design, market behaviours, consumer preferences, business models, corporate finance, and international relations. Innovation is an 'open' system with local, national and international dimensions, reflecting the growing linkages in science, research, product development, and the globalisation of businesses – even small businesses – as they participate in global markets and value chains. Around two thirds of innovation spending by companies in Australia is 'non-technology' innovation.

Innovation policy must therefore focus not only on the potential to apply ideas developed through research in science, technology, engineering and mathematics (STEM), but it must also give attention to research in the humanities, arts and social sciences (HASS). Innovation policy is concerned with how ideas are *diffused and consumed*, as well as how (and where) they are generated. The ability to sustain and grow start-up businesses and encourage established businesses to absorb ideas and capitalise on market opportunities critically shapes business success and the transformation of entire industries and economies.

[1] Australia. Review of the National Innovation System (Cutler Review), (2008)
[2] The Senate. Economic References Committee, (2015)

PART I: THE CONTEXT OF THE INQUIRY

This Part of the Report addresses the relationship between innovation and productivity, the current commitment to research and innovation, the innovation policy setting, and innovation system performance. It provides the background and rationale for five recommended Strategic Action Areas in Part II.

The innovation imperative

It is widely acknowledged that Australia faces a challenge in identifying new sources of growth and productivity in the post-mining boom economy. Associated with this challenge is a need to change from a 'commodity culture' to an 'innovation culture', which can establish higher economic complexity through *knowledge-based products and services* in global markets and value chains.

Advances in digital and other enabling technologies are transforming some commodity industries into 'high tech'. But these industries only employ a small number of workers. It is therefore important to develop other parts of the economy, particularly in advanced manufacturing and services, where there are untapped opportunities for innovation and the creation of high skill, high wage jobs. Australia can also build on its already strong mining, energy and agriculture base and extend it into *value added* products and services through the application of science, advanced technologies and creative talent.

Australia must be able to respond to and capture the opportunities of changing patterns of international trade, especially through our closer economic ties with China, India and the Asia-Pacific region. At the same time, like other countries, Australia also faces the challenges of climate change, urbanisation and securing a sustainable energy future. The Australian Academy of Technological Sciences and Engineering (ATSE) notes that technological change and innovation has always been central to human existence, and will continue to be a significant part of Australia's future[3].

Innovation and productivity

Australians are good at the development of new ideas, whether through scientific discovery, technological invention or the ingenuity of clever people. But we are not good at transferring them into innovations and ensuring their *diffusion* to lift firm level productivity and national economic performance. We must capture value from innovation in a way that secures prosperity, higher living standards, social inclusion and resource sustainability.

The OECD's recent report on *The Future of Productivity*[4] identified four factors that need to function well for effective diffusion to take place. These are summarised in Box 2 as global connections, new technologies and business models, 'matchmaking' and non-technology innovation, such as management practices and organisational know-how.

[3] Williamson, Raghnaill, Douglas, & Sanchez, (2015)
[4] OECD, (2015a)

Box 1: Strategy for Future Growth

Future growth will depend on harnessing the forces of knowledge diffusion that propelled productivity growth for much of the 20th century. But what keeps firms from adopting the right combination of technological and organizational innovations?

The list of obstacles to diffusion is long. Four key factors need to function well for effective diffusion to take place.

First, global connections need to be extended and deepened, so that firms can learn from successful counterparts across the world. This requires trade, foreign direct investment, participation in global value chains, and the international mobility of skilled labour.

Second, new firms need to be able to enter markets and experiment with new technologies and business models. The productivity slowdown coincided with a near-collapse of overall business investment and a slowdown in business dynamism, reflected in a decline in business start-ups. These trends need to be reversed.

Third, better 'matchmaking' is needed across the economy, to ensure that the most productive firms have the resources—labour, skills, and capital—to grow. The larger the frontier firms become, the greater the extent to which their good performance gets reflected in overall economic growth. Unfortunately, the most productive and dynamic firms do not always grow to optimal scale. In some economies, the most advanced firms have productivity levels close to the global frontier, but they are under-sized relative to their peers in other countries. Inefficient resource reallocation—which can be caused by lack of product competition, rigid labour markets, failure to exit, or non-performing loans—doesn't just keep frontier firms from growing. It also slows the diffusion of best practices to other firms.

Fourth, investment in innovation should extend beyond technology to include skills, software, organisational know-how (i.e. managerial quality). Innovation depends on the bundling of these investments, and policy initiatives should reflect that.

https://hbr.org/2015/08/productivity-is-soaring-at-top-firms-and-sluggish-everywhere-else

Science, technology and innovation

There is a clear link between technological progress, innovation and economic prosperity. Policy makers take a close interest the level of national investment in research and development (R&D) with the expectation that this will lead to breakthroughs in scientific discovery and technological inventions that can be adopted and applied to create new industrial infrastructure, new production processes and new or improved products and services.

Previous breakthrough technologies have included steel-making, water and then steam power, electricity, the internal combustion engine, the railway, the telephone, and reticulated urban water supply (impacting on human health). These breakthroughs are often attributed to the practical insights, ingenuity and business acumen of individual inventors. In the contemporary environment technological progress is increasingly *knowledge and theory based,* drawing on *research undertaken by teams* in the natural, physical and life sciences, technology, engineering, and mathematics (STEM) and the application of design and design thinking[5].

Box 2: The scope of STEM

The scope of science in STEM covers the enabling disciplines within the natural and physical sciences. These encompass: astronomy and the earth sciences, physics, chemistry, the materials sciences, biology and biomedical science. These sciences rely on causal relationships, characterised by systematic observation, critical experimentation, hypothesis formation and falsification.

Engineering is a profession that draws on the knowledge and methods of science, but science is far from sufficient for successful practice. Real-world engineering must address and solve immediate problems, sometimes without the luxury of abundant or complete knowledge taking account of aesthetics and uncertainties.

Technology provides goods and services to satisfy real-world needs. Building on the growing importance of information and communication technologies as the Internet has developed, technology increasingly encompasses the cross-section of knowledge and skills that drive the advance of the business, government and non-government service sectors – the so-called service sciences.

Engineering and technology are critical factors in the long-term economic growth of modern industrial societies. They function within the larger social environment to sustain the innovation process. The output of engineering and technological activities is a product or a service that must eventually stand the test of users and the marketplace.

http://www.chiefscientist.gov.au/wp-content/uploads/STEMstrategy290713FINALweb.pdf

STEM research is often revealed in a range of *platform and enabling technologies* such as micro/nano-electronics, nanotechnology, semiconductors, advanced materials, photonics, analytics, advanced manufacturing, biotechnology and information and communication technologies[6]. Many of these advances can be traced to public investment in basic, or fundamental, research undertaken in large-scale (and expensive) research facilities.

Enabling technologies have a major influence in the development of new products, processes and ways of doing business. They drive national productivity and international competitiveness not only in

[5] There is a historical link between technology and design, established in the manufacturing revolution in the 19th century. Burton, (1999)
[6] New enabling technologies will emerge over time, building a dynamic element into the course of innovation and growth.

'goods producing' industries, such as manufacturing, defence, agriculture, and mining, but also in service industries, including construction, merchandising, logistics, transport, health, education, commercial services, public administration, culture and the environment. The services sector makes up around 80 per cent of the economy.

The full extent of the contribution of science and technology to services is not easily visible to those outside the process. Accordingly, it can be under-appreciated by policymakers and the academic research community[7]. This 'blind spot' can hinder the development of effective innovation policies and the development of new business models and practices by giving too little attention to services industries.

In comparison to other OECD nations, Australia is underinvesting in science, and particularly the physical sciences (chemistry, physics, and mathematics and material sciences). The CSIRO has undertaken an analysis of Australia's relative scientific specialisation as part of its submission to the Boosting the Commercial Returns from Research Review[8].

Box 3: The current pattern of Australian research investment in STEM

CSIRO analysis indicates:

- Australian science has a specialisation in the fields of geosciences, environment/ecology, and plant and animal sciences. This most likely reflects the long-standing importance of the mining and resources and agricultural sectors of the Australian economy and the direct financial support provided by Commonwealth and State Governments (the former Bureau of Mineral Resources, Rural RDCs, and State Agricultural Research Institutes).
- Publications in these fields are more than 5 per cent of global publications, whereas, Australia produces 3.5 per cent of total global publications. Research quality in these fields also performs well with each of the three fields being at least 30 per cent more cited than the global average and at least 9 per cent more cited than the EU-15 average.
- In the fields of chemistry, physics, mathematics, engineering and materials science Australian output is between 1.7 – 2.6 per cent of global publications.
- Although it may not be contemplated that the Australia will become a global leader in sectors that require intensive physical sciences, these fields of sciences are fundamental to many sectors of the economy including the manufacturing and service industries.

Development or expansion of scientific capability in key discipline fields will require multiple decades of investment. With limited resources, there is a requirement to build capability in the science, research and innovation system to address the current underweighting of the physical sciences and to support delivery of innovation outcomes in the Australian economy up to 2020 and beyond.

A national innovation priority must be step level increases of investment in science and research in areas of strategic national importance, and a commitment to ensuring necessary infrastructure is in place to translate this investment into innovation outcomes that deliver national productivity improvement and international competitiveness.

Innovation and industry transformation

Innovation is key to the development and application of *digital technologies* – the use of digital resources to find, analyse, create, communicate and use information, and to develop and apply software. Digital technologies also enable the development new technological frontiers such as big data, data analytics, artificial intelligence, and 'the Internet of Things'. Digital technologies are ubiquitous – they are everywhere.

Digital technologies are disrupting and transforming industries as well as the way organisations and people interact and communicate. Their pervasive impact is opening many new opportunities for value and wealth creation and leading to the birth of new industries and firms[9]. The disruptive impact of digital technologies is often illustrated by reference to the entertainment, newspaper, photography, video hire, recorded music, and financial services industries. Postal services are currently being

[7] The Royal Society, (2009)
[8] http://www.industry.gov.au/INDUSTRY/INDUSTRYINITIATIVES/Pages/Boosting-the-Commercial-Returns-from-Research.aspx
[9] The contemporary concept of disruption originated in the work of Clayton Christensen Christensen, (1997; Dyer, Gregersen, & Christensen, (2011). Some researchers have argued that the theory of disruptive innovation has become too generalised. King & Baatartgtokh, (2015; Lepore, (2014)

disrupted in the way letters based communication is being superseded by digital communication[10]. Disruption is also occurring in health services and education[11].

Digital disruption has become a focus of attention in Australian Government services with the formation of the Digital Transformation Office.

Box 4: The Digital Transformation Office (DTO)

Digital Transformation Office: making government more accessible[12]

The government sector in Australia is a third of the economy so it makes sense to deliver services as efficiently and as cost effectively as possible. By making greater use of the Internet, governments will not only improve their own productivity, they'll also save users time when dealing with government.

Government needs to embrace digital and design services that are simpler and more convenient to use. That's why the Australian Government has established a Digital Transformation Office (DTO) - to not only make government more accessible and responsive, but to also improve the quality and availability of digital services.

The DTO will work with the D5 group of leading digital governments – from South Korea to the UK - to learn from their successes, while also recognising exemplars closer to home. Services NSW, in conjunction with Salesforce, is disrupting the NSW Government's traditional service model and the Australian Government's myGov, with more than six million users, will provide the DTO with an excellent platform to leverage.

The potential for the DTO to transform and disrupt is boundless. The only thing that will prevent the DTO from succeeding is our imagination, not technology itself. The first and most important step towards success is to put citizens at the heart of government operation.

The New South Wales Government has announced plans to establish Australia's first whole-of-government data analytics centre to limit bureaucracy and improve regulation and innovation efforts. This centre is being established by the Department of Finance, Services and Innovation during its start-up phase and, like the DTO, will be hosted at the University of Technology Sydney. After the first 12 months, management will be transferred to the Department of Innovation and Better Regulation[13].

The same forces are at work in manufacturing, which is being transformed by digital technologies and has now become an important source of future growth and productivity for Australia. It comprises the application and coordination of information, automation, computation, software, sensing, networking, and the use of cutting edge materials and emerging capabilities enabled by technology and design-led innovation. It underpins the high level of economic complexity that is the driver of national prosperity in most advanced nations.

Supply and distribution arrangements are also being disrupted as manufacturing businesses increase their participation in global value chains and establish deep collaborations with suppliers, contractors, and business partners. These include innovation providers, such as software companies, professional specialists, universities and research organisations. The capacity to collaborate is recognised as a major source of competitive advantage and national innovation policy needs to promote and reward it.

Small and medium-sized businesses, which are at the core of Australian manufacturing, construction and service industries, have been slow adopters of digital technologies. This is often due to a lack of awareness, firms' cultures and traditions (particularly in family owned businesses), lack of expertise, and IT hardware and software cost. These factors have the potential to 'exclude' businesses from innovation opportunities.

The skills for innovation

There is an emerging consensus that Australian workers must be equipped not only with knowledge and skills in science, technology, engineering and mathematics (STEM), but also with skills in management and entrepreneurship, and 'boundary crossing' skills like problem solving, adaptability and design thinking in an environment of lifelong learning.

Knowledge and skills in STEM underpin Australia's potential to innovate and compete on the global stage. They are seen as critical to the success of R&D projects as well as the day-to-day operations of

[10] McKell Institute, (2015)
[11] Christensen & Eyring, (2011; Wildavsky, Kelly, & Carey, (2010)
[12] Extract from joint opinion piece by then Communications Minister Malcolm Turnbull and Vivek Kundra, former White House CIO and current Executive Vice President for Salesforce (*The Australian* March 31 2015).
[13] See http://www.cio.com.au/article/581132/nsw-see-australia-first-government-data-analytics-centre/

competitive firms[14]. STEM skills also build a broader base of capabilities that link to innovation, particularly if they encourage the participation of women and girls (see Box 6).

Box 5: The broader contribution of STEM skills

Science, Technology, Engineering, and Mathematics: Australia's Future.

- STEM skills are the lifeblood of emerging knowledge-based industries—such as biotechnology, information and communications technology (ICT) and advanced manufacturing—and provide competitive advantage to established industries—such as agriculture, resources and healthcare.
- An education in STEM also fosters a range of generic and quantitative skills and ways of thinking that enable individuals to see and grasp opportunities.
- These capabilities—including deep knowledge of a subject, creativity, problem solving, critical thinking and communication skills—are relevant to an increasingly wide range of occupations. They will be part of the foundation of adaptive and nimble workplaces of the future.
- Australian firms that actively embrace change as a normal part of business are around twice as likely to use engineering skills, twice as likely to use science and research skills, and three times more likely to use ICT skills.
- International research indicates that 75 per cent of the fastest growing occupations now require STEM skills and knowledge.
- The demand for STEM will only continue to grow as we compete in the emerging global economy.

Australia. Office of the Chief Scientist (Professor Ian Chubb). Science, Technology, Engineering and Mathematics: Australia's Future. Canberra: Australian Government, 2014.

There is a reported shortage of STEM skills in Australian industry. A 2014 Australian Industry Group survey of workforce development needs reported that almost 44 per cent of employers continue to experience difficulties recruiting STEM qualified technicians and trade workers. The main barriers are a lack of qualifications relevant to the business (36 per cent) and a lack of employability skills and workplace experience (34 per cent)[15].

Data reported by the Department of Education and Training[16] indicate that there were 162,283 full time equivalent (FTE) domestic students enrolled in STEM disciplines at Australian universities in 2014. This represented 23.8 per cent of total domestic university enrolments[17]. Just over a quarter (25.5 per cent) of STEM students were enrolled in biological sciences, with a further 14.6 per cent enrolled in mathematics. There is also a marked lack of gender diversity which must be addressed to draw on the full potential of society. Detail is provided in Table 1.

Table 1: Actual Student Load (EFTSL) for All Domestic Students by Narrow Discipline Group and Broad Level of Course, Full Year 2014

Narrow Discipline Group	Doctorate	Master's	Other Postgrad	Bachelor	Other	Total	Propn
Aerospace Engineering and Technology	60	83	150	1,062	107	1,463	0.9%
Automotive Engineering and Technology	0	8	0	31	0	39	0.0%
Biological Sciences	2,223	720	262	37,163	1,012	41,381	25.5%
Chemical Sciences	685	90	29	7,997	482	9,285	5.7%
Civil Engineering	449	717	104	7,947	319	9,536	5.9%
Computer Science	435	475	97	8,147	475	9,630	5.9%
Earth Sciences	458	195	74	3,602	109	4,438	2.7%
Electrical and Electronic Engineering and Technology	559	463	31	6,781	289	8,123	5.0%
Geomatic Engineering	59	121	61	1,265	184	1,689	1.0%
Information Systems	139	730	174	6,172	353	7,569	4.7%
Manufacturing Engineering and Technology	58	83	4	796	67	1,008	0.6%
Maritime Engineering and Technology	14	11	8	304	6	342	0.2%
Mathematical Sciences	386	615	362	19,380	2,970	23,713	14.6%
Mechanical and Industrial Engineering and Technology	407	310	57	6,508	217	7,498	4.6%
Physics and Astronomy	556	146	37	4,511	270	5,519	3.4%
Process and Resources Engineering	403	313	220	3,766	156	4,859	3.0%
Other Engineering and Related Technologies	369	621	111	6,221	388	7,710	4.8%
Other Information Technology	186	440	84	3,869	448	5,027	3.1%
Other Natural and Physical Sciences	1,202	731	147	10,860	514	13,454	8.3%
	8,648	6,872	2,012	136,382	8,366	162,283	100.0%

Source: Department of Education and Training, All Student Load, 2014, https://docs.education.gov.au/system/files/doc/other/2014_all_student_load_0.xls

The extent to which the current pattern of university enrolments in STEM disciplines will meet workplace requirements in industry growth centres is an important matter for consideration. Studies

[14] Office of the Chief Scientist (Professor Ian Chubb), (2014)
[15] Australian Industry Group, (2015)
[16] Department of Education and Training, (2015)
[17] Other significant groupings were: Health (13.5 per cent), management and commerce (19.0 per cent), society and culture (24.0 per cent) and creative arts (8.1 per cent)

indicate that ICT knowledge and skills are required across *all* disciplines rather than on its own as a specific field of study. This exemplifies the role of ICT as a key enabling technology.

However, discussion about the delivery of STEM skills is most often directed towards the higher education sector, professional occupations, and connections with the research sector. It has tended to neglect the many para-professional and technical jobs that require considerable STEM knowledge acquired through a post-secondary certificate, diploma, or associate degree. Certification bodies often require VET based qualifications as a condition to work in a range of specialised occupations.

Skilled technicians produce, install and repair the products and production machines created by professional researchers and engineers, allowing firms to reach their markets, reduce product defects, create process innovations and enhance productivity. They also develop and maintain the nation's energy supply, electrical grid, and infrastructure[18]. The 2014 *Australian Innovation System Report* notes that:

> Just like higher education, the vocational education and training (VET) sector is an important adjunct to the national innovation system. Skills that are attuned to vocational situations and the actual needs of the workforce are required to ensure that new and improved products and processes have technical and commercial applicability. Workers often need a combination of knowledge acquired from higher education and vocational education to realise workforce gains[19].

Data provided recently by the National Council for Vocational and Education Research (NCVER), indicates that there were 3,581,000 enrolments in VET courses in 2014. Of these, 558,100 were in the fields of engineering and related technologies (15.6 per cent), 95,700 in information technology, and 17,200 in the natural and physical sciences. The largest field of education was management and commerce (20.6 per cent)[20]. Quite clearly the VET system has a major role in training people with STEM skills.

State/Territory TAFE colleges have a continuing and vital role in the development of technical STEM skills. It is imperative that this commitment be developed and maintained in collaboration with universities.

Skills in enterprise and entrepreneurship are also vital for innovation performance, not just for new ventures but also for established ones. A report prepared for the Office of the Chief Scientist sets out the way in which *universities* could teach entrepreneurial skills and provide an environment that encourages students to explore high-impact entrepreneurship as an alternative to traditional career paths[21]. The report finds the following desirable attributes for developing entrepreneurial skills:

- Strong engagement between the university and the local start-up ecosystem
- Courses delivered by experienced entrepreneurs and practitioners
- Students given multiple opportunities for engagement—ranging from short courses to immersive programs such as internships and overseas placements
- Programs that support multi-disciplinary collaboration, including STEM.

The UK has had a long tradition of encouraging, supporting and funding universities to deliver entrepreneurship skills. The *Higher Education Innovation Fund* has been an important and significant 'third funding' stream for English higher education institutions, with the aim of stimulating universities to reach out to business and the community[22]. There is no Australian equivalent.

Innovation in business

In business, technology is not necessarily a product differentiator. Breakthrough product technologies may never end up being applied in a competitive market situation, or they may be short lived. Differentiation occurs on the *demand side*, through design, creative content, marketing, distribution channels and service content, that all go towards establishing a sustainable customer base. Internationally, innovation support agencies give a very high priority to demand side drivers.

[18] Rothwell, (2013)
[19] Department of Industry, (2014)
[20] NCVER, (2015)
[21] Kinner, (2015)
[22] HEIF has been in operation for 16 years.

The development of innovation capability at the level of the enterprise requires knowledgeable and engaged managers who can structure relationships between technical skills, professional talent, creativity, and business outcomes. In undertaking these tasks managers are able to draw in new knowledge and ideas from the HASS disciplines such as management theory and practice, finance, economics, statistics and marketing.

The 2009 *Management Matters in Australia* study found that there is a clear link between the quality of management – scored across 18 dimensions of people, performance and operations – and enterprise productivity[23]. Knowledge and skills in STEM are of little value if they cannot be transformed into application and use in a business context. Many people with strong STEM capabilities have the potential to be great managers.

Although the issue of management capability was addressed many years ago in the *Karpin Report*[24], its analysis and findings remain valid, as may be seen from more recent studies. The report provided important insights into the way Australia prepares its managers for work and leadership. It gave particular attention to the need for an enterprise culture, globalisation, diversity, lifelong learning and enterprise and education institution best practice.

Design and creativity are also critical business drivers, as reflected, for example, in architecture, industrial design, music, film, video and internet businesses. These businesses require people with skills in digital technologies and management. Australian design businesses have achieved international success in these areas[25]. *Design thinking* has come into prominence in developing new business models to reach and engage with customers.

While design has gained some attention in the Australian context[26], little policy commitment has been evident. Internationally, innovation support agencies have given a high priority to design with exemplars being Denmark and the UK since the adoption of recommendations of the *Cox Review of Creativity in Business*[27]. There are a number of design centres and initiatives in Australia, but we do not have the equivalent of a UK Design Council, an organisation dedicated to improving people's lives through the use of design.[28]

Innovation policy *must* reflect the critical contribution of design and creativity. Consideration should be given to the formation of a National Design Council to guide policy, practice, and learning in this important aspect area of innovation.

Contemporary thinking about skills often makes reference to 'jobs', 'professions' or 'vocations'. But there are skills that transcend these categorisations and relate to new ways of working and adding value. They include what are referred to as 'soft' work-based skills and capabilities such as collaboration, new media literacy, social intelligence, and adaptive and computational thinking - the ability to translate vast amounts of information into insights, significance, and trends and patterns.

In the current business environment, where firms rarely have all of the capabilities required to deliver an innovation outcome, skills are required to source ideas externally from suppliers, distributors, customers and the research community through strategies of open innovation[29], crowd-sourcing solutions[30], and innovation contests[31], as well as more formal collaborations between firms and research organisations along global value chains.

The role and significance of start-up businesses

New technology-based firms are often regarded as the engines of innovation[32] and are receiving a great deal of attention in current policy discussions. Venture capital can be an important way of

[23] Green, Agarwal, & others, (2009)
[24] Australia. Industry Task Force on Leadership and Management Skills, (1995)
[25] International engineering and design businesses such as Arup, GHD, and SKM, have Australian origins.
[26] Buculo & King, (2014) Howard, (2008)
[27] Great Britain. Treasury, (2005)
[28] See http://www.designcouncil.org.uk/
[29] Chesbrough, (2003; Sloane, (2011)
[30] Howe, (2009; Libert & Spector, (2009; Sloane, (2011; Surowiecki, (2004)
[31] Terwiesch & Ulrich, (2009)
[32] Murray, (1996)

financing the rapid growth of these businesses, and reference is often made to 'Silicon Valley' in California. Silicon Valley has become the world's centre for venture capital investment.

The prototypical Silicon Valley venture start-up that flourishes in the venture capital setting has a technological solution to a mass problem – or opportunity. It produces something that has high margins and an expectation of being profitable in two to three years. Only a small number of new technology businesses, including those that are developing mobile and social media applications, can meet these criteria. Typically, a venture capital investor will fund about one in 100 business plans or 'pitches' lodged.

There is a flourishing very early stage venture capital sector in Australia with numerous early stage venture funds focussed on identifying and developing businesses in digital technology, social media and 'fintech'. However, access to follow on finance in Australia is more challenging. Businesses that are ready to go to the next stage of financing and growth are attracted to the much larger VC market in Silicon Valley with little flow on benefit to Australia.

Availability of early finance is a key issue for Australian start-up businesses, particularly in complex technology areas such as advanced manufacturing and mining, energy, and medical technologies where the Silicon Valley start-up model is more difficult to apply.

In the US, and around the world, the vast majority of start-up businesses are 'bootstrapped' – developed with minimal capital and an organic growth pattern[33]. Only about seven per cent of the *Inc 500* fast growing businesses have received venture capital. Funding for most start-up businesses might commence with modest personal funds[34], small amounts of equity funding from patient 'angel' investors, or family, with ongoing financing sourced from customers (profits and retained earnings), trade creditors, and banks providing working capital cover. Recently, crowd-funding has become an important source of capital for entrepreneurial start-ups.

Box 6: New beehive design raised $15 million from crowd-funding in just two months

When inventors Cedar Anderson and his father Stuart released their radical new design for a beehive on the crowdfunding platform Indiegogo in late February, they were hoping to raise $US70,000. When the campaign closed eight weeks later, it topped a staggering $US12 million ($AU15.375 million).

The pair, from the hippie-tinged rainforest hinterland of Byron Bay on the NSW far north coast, spent more than a decade creating a brilliantly simple, yet game-changing system that allows beekeepers to harvest honey on tap, without disturbing the hive. The plastic honeycomb cells are cracked opened with a lever so honey drains down and out before the cells are reset, ready to be refilled. The method also saves hours of time and effort for beekeepers.

The global reaction has been astonishing, with more than 35,000 people investing in the FFlow Hive project, including 7000 buying the now sold out $US600 full beehive. Within three hours, they'd raised $US1 million. The project has become Indiegogo's biggest ever crowdfunding project.

Simon Thomsen, *Business Insider*, April 20 2015, http://www.businessinsider.com.au/this-amazing-new-beehive-design-has-now-raised-15-million-from-crowdfunding-in-just-two-months-2015-4

Research undertaken by the Office of the Chief Economist found that young SMEs (firms aged 0–5 years) made the highest contribution to net job creation in Australia (40 per cent) and start-up activity (firms aged 0–2 years) is responsible for most of this growth. A very small fraction (3.2 per cent) of these micro start-ups grow dramatically over five years post-entry and these firms account for the majority (77 per cent) of total post-entry job creation of all micro start-ups in their cohort[35].

Numerous case studies indicate that successful and sustainable start-up businesses are led by entrepreneur owners who have a passion for selling something of value to a customer. As they grow they have a need to develop *organisational* capabilities in management, R&D, innovation, processes and systems, workplace relations, quality, networks and trust based relationships, and above all, marketing and market access. They generally like to retain ownership of their IP.

A policy priority should be supporting potential high growth start-ups as a way of speeding up the business development process through: building management capability; developing networks and a culture of collaboration; facilitating new market development; and strengthening organisational and governance capabilities.

[33] Bhidé, (2000)
[34] For university-based startups, a range of institutional sources is providing funding to get startups off the ground. See Howard, (2015)
[35] Hendrickson, Bucifal, Balaguera, & Hansellb, (2015)

These measures should be available through *one* enterprise development agency that integrates support available on the *production* side (research and development, scale up and piloting) with those on the *demand* side (market access, trade facilitation, participation in global value chains)[36].

Around the world, the evidence suggests that start-up businesses need and have a great potential to thrive in local and regional innovation ecosystems. Local networks, business incubators and accelerators are emerging as important elements of these ecosystems across Australia, particularly in CBD locations of major cities, or in locations where there is a strong university presence. Universities and a range of committed early stage investors financially support them, and in some cases provide both soft and hard infrastructure.

When put in collaborative 'hot-house' conditions, SMEs can scale very fast and create employment. Collaboration can also contribute to working through 'red tape', such as securing quality certification, safety regulations, and obtaining licenses to sell products to customers both domestically and internationally.

Incubators, accelerators and co-working spaces provide an environment where expertise can be shared, failures dissected and then learned from, inspiration cultivated, and investments made. They work best in geographically concentrated local start-up communities in close proximity to research and education institutions.

Innovation for sustainable growth

In recognition of the broader role of science in society, OECD members committed in October 2015 to the *Daejeon Declaration on Science, Technology, and Innovation Policies for the Global and Digital Age* (See Box 7).

Box 7: OECD Daejeon Declaration on Science, Technology, and Innovation Policies for the Global and Digital Age

OECD shared vision for science, technology and innovation:

- Improve the quality of life for all our citizens as they increase employment, productivity and economic growth in a sustainable manner over the long term;
- Provide new opportunities for investment, both for start-ups and established firms, in developed and developing countries; and,
- Meet global and societal challenges, such as environmental sustainability, climate change, developing new sources of energy, food security and healthy ageing, hence achieving the Sustainable Development Goals agreed by the United Nations.

http://www.oecd.org/sti/daejeon-declaration-2015.htm

This Declaration reflects in increasing interest in global policy balancing disruptive growth with inclusive and more sustainable growth strategies, including interest in the concept of the 'circular economy'. This is an approach where resources are kept in use for as long as possible, and action is directed towards extracting the maximum value from them whilst in use, then recovering and regenerating products and materials at the end of each service life.[37]

The OECD has also reported that governments are seeking to spread the benefits of increased prosperity more evenly across the economy and society[38]. Inclusive innovation policies enable low productivity entrepreneurs and firms to boost their economic performance, and lower-income groups to improve their welfare. This means exploring the relationship between innovations aimed at competing on global markets with innovations aimed at securing greater industrial and societal inclusiveness.

Inclusiveness occurs through 'democratisation' (extending participation) and 'distribution' (sharing the benefits more widely). Digital technologies have supported initiatives along both dimensions[39]. For example, the recent *Digital Post* report[40] canvassed the prospect of rural and

[36] In Finland there is evidence to support the view that policies supporting high growth start-ups can have significant impact Autio & Rannikko, (2015)
[37] European Commission, (2015) and http://www.mckinsey.com/insights/manufacturing/moving_toward_a_circular_economy
[38] OECD, (2015b)
[39] http://www.oecd.org/sti/inno/Symposium%2020-21%20March_Summary_Record.pdf. See also OECD, (2015c)
[40] McKell Institute, (2015)

remote post offices becoming 'digital hubs' to include people who could otherwise be 'digitally excluded' from communicating in the changing economic and social system.

Achieving inclusiveness in terms of gender, socio-economic disadvantage, minority groups, and people using English as a second language, should also be an important part of policy discussions and the development of innovation support measures.

Policies on innovation, sustainability and inclusive growth must be designed in a comprehensive and interconnected way if they are to be effective.

Social and cultural innovations play an important role in the innovation system, and are often overlooked in policy discussion and analysis. Social innovations create new solutions and 'shared value' for society, or groups within society[41]. Australia has generated some significant social innovations, such as the Higher Education Contribution Scheme (HECS), a contingent loans scheme for tertiary education students.

Cultural innovations impact on societal beliefs, attitudes and behaviours. Australia has achieved marked success in changing attitudes and behaviours in areas such as multiculturalism, discrimination, biodiversity protection, water and energy use, drink driving and smoking. We can now observe a further process of cultural change in relation to innovation and entrepreneurship.

There is a momentum building within the science and business community to establish a *culture of entrepreneurship* that would support innovation in terms of taking risks and investing time and resources to start and build businesses that have the capacity to enter global markets.

The Australian innovation system policy setting

Commonwealth policy roles and responsibilities

Under current Administrative Arrangements, the Minister for Industry, Innovation and Science has policy roles to support science and commercialisation, grow business investment, improve business capability and streamline regulation.

Several other Minsters also have science, research and innovation roles, including the Ministers for Agriculture (rural research, water), Communication and the Arts (internet and digital technologies), Defence (defence science and technology), Education and Training (research, higher education, vocational education and training), Environment (climate, oceans, biodiversity), Foreign Affairs (ACIAR, InnovationXchange), Trade (export market development, trade advice, market access), Health (medical research), Infrastructure (regional development), and Treasury (the taxation system, capital market issues).

Over the last 15 years there have been at least 60 Commonwealth Government ministerial policy statements, government commissioned reports, reviews, and information papers that address innovation system issues. There has also been a stream of policy reviews and position papers. These are listed in Attachment 2.

There is, in addition, a copious quantity of consultants' reports and advocacy documents issued by industry organisations, professional services businesses, academic associations, and learned academies. There is, regrettably, very little cross-referencing, prior attribution, and generally building on the insights and analyses presented in these reports and papers.

The volume of reports, reviews and advocacy contributions reflects a remarkable discontinuity and instability in the science, research and innovation policy setting. Our knowledge of the innovation system has tended to be non-cumulative in its orientation, and there has been very little 'system learning'.

[41] Porter & Kramer, (2006) and https://www.gsb.stanford.edu/faculty-research/centers-initiatives/csi/defining-social-innovation

System complexity

The present status of measures that underlie Australian Government support for science, research and innovation appear to be the outcome of:

- Frequent changes in Ministerial and department functions and structures
- Separate and disconnected decision and resource allocation processes between many government departments and research funding agencies
- Regular (at least bi-annual) expenditure review processes and 'slash and burn' approaches arising from periodic Commissions of Audit
- Differential strengths in policy lobbying and advocacy by sector based industry associations and professional associations
- Very little independent evaluation through high quality research

Government science, research and innovation measures have therefore tended to be short term, inadequately funded, and prematurely terminated. Some interventions have lacked a strong evidence base whilst others have operated with limited reporting of outputs and outcomes, and minimal evaluation.

Evaluations, when conducted, are performed under a political or fiscal threat of termination. This is in contrast to the European approach of learning from past experience and improving effectiveness. Only a few measures, such as the Cooperative Research Centres (CRC) Programme, have operated over an extended time period, with evaluations undertaken approximately every five years[42]. The high turnover of measures creates uncertainty in business, which in turn, impacts on investment decision options and reinforces investment short-termism.

Action must be taken to build coherence into the science, research and innovation system by establishing strategic goals for the main elements, removing duplication and overlap, looking for complementarity, and consolidating programmes and interventions into organisations that are stable, have continuity beyond the term of governments (and Ministers), and are outcome oriented.

State and Territory government involvement

State/Territory governments have been major investors in research for many years. ABS data indicates that in 2012-13 State/Territory governments allocated $1.4 billion to R&D, of which 40.1 per cent was in agriculture, a further 34.7 per cent in health, and 15.8 per cent in the environment. Manufacturing R&D stood at 0.5 per cent of expenditure.

State/Territory governments provide a range of support measures for science, technology and innovation within their jurisdictions[43]. Like the Commonwealth, there is discontinuity due to fiscal austerity and frequent changes in Ministerial roles and responsibilities. State/Territory governments are currently implementing science, research and innovation policies and support measures that aim to increase business interaction with research organisations.

Box 8: The Advance Queensland Strategy

In July 2015 the Queensland Premier launched a $180m *Advance Queensland* strategy. It has four main elements:

- A $50m Advance Queensland Best and Brightest Fund, which will develop, attract and retain world-class talent both scientific and entrepreneurial
- A $46m Advance Queensland Future Jobs Strategy that will open the door to new industry/research collaborations, tackle the big innovation challenges, focus on translation, and deliver 10 year roadmaps for industries with global growth potential
- A $76m Business Investment Attraction package, which will encourage a new wave of Queensland start-ups, support proof-of-concept projects and attract co-investment through the Business Development Fund
- $8m is set aside to provide flexibility to respond as new opportunities arise, especially roadmaps with industry partners are developed.

http://advanceqld.initiatives.qld.gov.au/

Most States have appointed Chief Scientists/Engineers who have a role in building relationships with the research community, as well as with other stakeholder groups. State/Territory Governments are looking to public research organisations to support initiatives in their own industry development

[42] The CRC Programme was instituted in 1992.
[43] See Howard, (2015)

priority areas. Commonwealth and State/Territory innovation leaders also work together through the Commonwealth State and Territory Advisory Council on Innovation (CSTACI) and Chief Scientists meet regularly. But there is scope for greater collaboration on policy development and program delivery directed towards a more coherent and effective national innovation effort, while at the same time recognising inevitable differences between Commonwealth and State/Territory priorities.

Local innovation ecosystems

In the US, Europe and many other parts of the world, the concept of an innovation ecosystem is attracting the attention of policy makers. It is a term that describes the large number and diverse nature of participants and resources that are necessary for innovation[44]. Participants include large businesses, entrepreneurs, technology investors, universities and other public research organisations, VET providers, business and industry associations, and a range of technical and professional service providers (accountants, lawyers, designers, engineers, management consultants).

Local businesses, local governments, business organisations, regional development agencies, universities, and VET and providers have emerged as key players in supporting the expansion of regional and local innovation ecosystems in the cities and regions where they are located. They have supported business incubators and accelerators, seed and venture capital funds, technology parks and precincts, and urban land development[45].

Local innovation ecosystems are emerging almost organically in capital cities and regions. Knowledge creation and translation organisations including universities and VET providers have become key players in support of innovation in the cities and regions where they are located.[46]

By contrast with many other parts of the world, most university initiatives in Australia have been taken in the absence of clear policy direction and support from government. Australia is now at a point where it would be advantageous for governments at all levels to build on and be supportive of initiatives that are cost effective, add value and provide a foundation for research, business and community collaboration.

A distributed system - and the implications

Australia's innovation system reflects a wide diversity in structure and relationships. It has evolved as a 'distributed' arrangement with the Commonwealth Government taking on national roles and the States/Territories, universities, and VET providers developing measures that are directed towards their own jurisdictions and innovation ecosystems.

Establishing and maintaining connections through coordination, networking and collaboration are therefore important factors in the effective performance of the *Australian* innovation system. There is much to be said for the European concepts of 'subsidiarity' (devolving policy implementation to the level of optimal impact) and 'additionality' (ensuring funding at each level adds value rather than duplicating or counteracting existing programs). Problems often arise less from market failure than from 'systems failure'[47]

Within this distributed framework, barriers, gaps and broader systems failure can occur where policies are determined and decisions taken in one part of the system that might seem like a good idea in isolation but which could have potentially adverse effects in other parts of the system. This results in misallocation of resources, inefficiency and reduced effectiveness in securing improved innovation capability and performance.

[44] See Department of Business Innovation and Skills (2014) 'Insights from international benchmarking of the UK science and innovation system' BIS Analysis Paper 03, January 2014 https://www.gov.uk/government/publications/science-and-innovation-system-international-benchmarking, and European Commission (2012) 'Communication on the European Research Area' http://ec.europa.eu/research/era/era_communication_en.htm

[45] A detailed analysis has been undertaken for the Council of Learned the Academies Howard, (2015). See also OECD, (2008; Victoria. Department of Innovation Industry and Regional Development, (2009)

[46] See for example, Brisbane Innovation Scorecard, which comprehensively provides local information from which to make good policy decisions. http://www.enablebrisbane.com.au/Enable2013/innovation-scorecard/brisbane-innovation-scorecard-overview

[47] Dodgson, Hughes, Foster, & Metcalfe, (2010)

Arrangements for cooperation and collaboration between elements of the innovation system architecture to achieve innovation outcomes within and between governments are not well developed in Australia. There is an urgent need for policy leadership, system stability and consistency in approach.

Key institutions in the Australian innovation system

This Section of the Report outlines the role of key institutions in the innovation system – universities, business, government, research organisations and VET providers – against the background of assistance and support provided through the Commonwealth Budget.

Commonwealth investment in science, research and innovation

In 2015-16 the Commonwealth Government will invest $9.7 billion in support of science, research and innovation. Details of this expenditure are provided in Appendix 1. A summary of investment for 2007-08, 2011-12 and 2015-16 is provided in Table 1 below.

Table 2: Commonwealth Government programmes for science research and innovation 2007-08, 2011-12, 2015-16

Portfolio / Activity	2007-08 $m	% of Exp.	2011-12 $m	% of Exp.	Budget 2015-16 $m	% of Budget
Australian Government research activities (CSIRO, DSTO, ANSTO, other)	1,639.3	24.4%	1,770.4	17.5%	1,805.5	18.6%
Higher Education sector *(ARC grants, Performance funding, and other)*	1970.9	29.3%	2760.8	27.3%	2828.0	29.1%
Health (NH&MRC grants and other)	621.9	9.3%	1,078.3	10.7%	904.0	9.3%
Cooperative Research Centres	211.9	3.2%	165.5	1.6%	146.7	1.5%
Rural RDCs and other Rural	231.5	3.4%	270.3	2.7%	304.5	3.1%
Business Enterprise sector (R&D tax measures, business programs)	1725.7	25.7%	3367.2	33.3%	3161.1	32.5%
Other	*234.0*	3.5%	*482.8*	4.8%	*204.2*	2.1%
Total Australian Government support	**6,718.7**	**100.0%**	**10,109.4**	**100.0%**	**9,717.0**	**100.0%**

Source: Department of Industry Innovation and Science. "Science, Research and Innovation Budget Tables." Canberra: Department of Industry Innovation and Science, 2015.

Many have questioned whether this investment represents the best possible allocation of available resources for science and innovation. The information in Table 2 does not include Commonwealth funding for teaching in universities, notwithstanding the long-standing link between teaching and research, the Vocational Education and Training (VET) sector, the net cost of Intellectual Property administration (IP Australia), or departmental policy and programme administration costs.

It must be acknowledged of course that Government expenditure on research has multiple objectives ranging from pure public good, such as understanding culture, history and our place in the universe, to applied research with specific relevance to innovation outcomes. Moreover, some research expenditure is designed to facilitate the movement of knowledge from abroad, as Australia cannot aspire to global research excellence in all fields and must connect to wherever it is in the world and draw it in.

Submissions to the Inquiry generally advocated a *greater* budgetary commitment for public sector research and industry facing innovation schemes particularly in the light of reductions in some areas. But even within the current funding envelope, it is not clear that the allocation of resources is optimal.

The largest single reported component of expenditure in Table 1 is the R&D Tax Incentive. In 2015-16 the cost of the incentive is estimated to amount to $2,929m, or 30 per cent of expenditure. Given that this is 'undirected' funding, some have argued that it is a cost effective expenditure, while others have proposed reallocation of the funding to more targeted approach outcomes.

In a budget-constrained environment, an argument for increased commitment to science research and innovation can only be sustained on the basis of a well-structured innovation system. It is therefore important to develop priorities, improve policy coordination, and reallocate resources with the aim of improving overall innovation system performance and outcomes in a way that produces greater societal benefits than alternative government investments.

Universities

In 2015-16 Australian Government funding specifically for research in Australian universities is estimated to amount to $2.8 billion. The major sources of funding are the Australian Research Council and programmes administered through the Department of Education and Training. Details are set out

in Table 3. Funding specifically for university research represents two-thirds of the $4.2 billion made available for public research in the 2015-16 Commonwealth Budget (see Table 8 on page 40).

Table 3: Australian Government funding for university research ($m)

Programme / Activity	Estimated Actual 2014-15	Budget Estimate 2015-16	Distribution (%)
Australian Research Council (ARC)	853.1	789.7	27.9%
Research Training Scheme	676.7	649.8	23.0%
Joint Research Engagement Program	356.1	360.2	12.7%
Australian Postgraduate Awards	276.1	282.1	10.0%
Research Infrastructure Block Grants	239.4	242.1	8.6%
Sustainable Research Excellence in Universities	185.4	238.7	8.4%
National Institutes Program - ANU Component	191.3	192.3	6.8%
International Postgraduate Research Scholarship	22.2	22.4	0.8%
Collaborative Research Network Program	10.3	9.3	0.3%
Household, Income and Labour Dynamics in Australia (HILDA) Survey	10.1	9.3	0.3%
Research Investment Adjustment Scheme	0.0	8.0	0.3%
Longitudinal Survey of Australian Children (LSAC)	8.5	7.8	0.3%
Funding for Higher Education Research Promotion	4.7	4.7	0.2%
Department of Veterans' Affairs Applied Research Program	2.5	2.5	0.1%
National Disability Research and Development Agenda	0.1	2.1	0.1%
Environmental Water Knowledge and Research	1.9	1.9	0.1%
Other	6.4	4.9	0.2%
	2,844.8	2,828.0	100.0%

Source: Department of Industry Innovation and Science. "Science, Research and Innovation Budget Tables." Canberra: Department of Industry Innovation and Science, 2015.

Individual universities do not publish information about research expenditure. The Australian Bureau of Statistics estimates that in the 2012 calendar year total higher education expenditure on research and development (HERD) amounted to $9.6 billion[48]. More than half of university research is funded from internal sources, including student fees, financial and property investments, philanthropy, business income and a range of fees and charges

Universities have a major role in the innovation system through their responsibilities in research and education. That role is defined within the overall mission, purpose and operating framework as public organisations established under a State/Territory Government statute. A range of specific purpose and conditional funding arrangements established by the Commonwealth Government has a strong influence on the operating framework.

On a day to day basis universities operate in accordance with the priorities and policies agreed by their governing boards (Councils/Senates). Several Australian universities are, in fact, very large businesses, with revenues approaching $2 billion. Most have AAA credit ratings and have strong balance sheets, taking a highly prudential approach to investment and risk. They have governance policies covering investment and equity in non-controlled entities that would cover start-up companies.

All universities have strategies, plans and budgets covering research, teaching, international connections and industry engagement. They compete aggressively, nationally and globally, for research income, students and brand identity. A high position in international rankings is an important element in this competitive environment, though rankings methodologies vary considerably. This has significant consequences for the innovation system.

Submissions to the Inquiry, policy statements and position papers released by industry associations, professional organisations and consultants over the last 12 months have called for improved relationships and interactions between universities and industry[49] and for universities to make a greater commitment to becoming more relevant to industry needs. This raises an important issue in the balance of university research endeavour.

[48] Australian Bureau of Statistics, (2014)
[49] For example Business Council of Australia, (2014)

In October 2015 Universities Australia outlined in a policy statement *Keep it Clever* a commitment to make an active contribution to innovation outcomes (see Box 10).

Box 9: Universities Australia *Keep it Clever*

Universities have committed to:

- Drive the innovation needed to secure national economic and social wellbeing.
- Produce the next generation of researchers and career-ready graduates that are digitally literate and entrepreneurial to create and fill the jobs of the future.
- Engage more closely with all sectors, particularly industry, to grow the economic and social benefits that flow from university research.
- Collaborate with international partners to build national research capability, pursue research excellence and contribute to the international research effort to address the most pressing global challenges.
- Foster new ventures and expand the level of public and industry access to the outcomes of university research.
- Maintain accountability to governments and the community for the efficient deployment of the public funds they receive to further the nation's research endeavours.

Keep It Clever: Policy Statement 2016.Canberra: Universities Australia, 2015 https://www.universitiesaustralia.edu.au/news/policy-papers/Keep-it-Clever--Policy-Statement-2016#.VhYbUxOqpBc

There is a popular view that university 'researchers' should spend less time pursuing research 'excellence' in their own areas of scholarly interest, and more time on being relevant to, and engaging with, industry. There is some merit in this view in terms of university research strategies striking a balance between investigator-initiated discovery research, mission-driven strategic research and industry-facing research. This is addressed as part of Strategic Action Area 3 (see page 42).

Research excellence and research relevance to industry are not mutually exclusive undertakings. Many leading researchers enjoy a very strong engagement with industry. It has been demonstrated in the UK that excellence is actually a prerequisite for relevance, but the UK has also taken steps to build an 'impact' factor into their research measurement framework[50].

Australian university researchers involved in basic research tend to have higher levels of engagement with overseas-based corporations than with local small and medium-size firms. Similarly, large Australian businesses work with overseas research organisations that are undertaking path-breaking research that is relevant to their interests. Some Rural RDCs, for example, invest internationally on behalf of Australian agricultural and food businesses through the industry levy system.

Many industry submissions to the Inquiry made reference to difficulties that industry finds in working with universities. Others were very supportive of the way relationships had developed and are maintained. There are, for example, strong relationships established over many years, in the mining, energy, agriculture and health/medical sectors. But collaboration is less apparent in manufacturing, and particularly small business manufacturing.

Challenges in developing stronger university-industry relationships include:

- *Academic career advancement and career aspirations* – career progress is generally determined by achievement in scholarly research and less in undertaking assignments that are relevant to industry. These are generally covered in staff Performance Agreements and criteria for granting tenure. Commissioned research for industry is highly regarded, but fee for service consultancy is not. Yet consultancy can be the foundation on which other forms of university-business relations develop.[51]
- *Ethics procedures* - universities adhere to rigorous ethics procedures and must ensure that research is independent, credible and objective (and indeed the community has high expectations in this regard). However, ethics clearances can take time and are sometimes cumbersome.
- *University policies relating to 'outside work'* – in some universities this is encouraged, whilst in others it is banned (but undertaken under the radar). In the US academic staff are encouraged to work in their consultancy businesses, a practice that is frowned upon in most Australian universities.

[50] See Perkmann et al., (2015) The report shows that that convincingly shows that better engaged researchers publish more, win more grants and get promoted more.

[51] Etzkowitz, (2002). Etzkowitz identifies the origin of the 'one day a week' rule at MIT, which was intended to encourage industry collaboration. It was adopted in Australian universities, but is now less common.

- *Finding university 'entry points'* - it can be difficult for businesses to find academic staff to discuss collaborations. Some universities, but by no means all, have industry engagement tabs on their Home Page and have established websites that profile their staff expertise.
- *Overhead costs* – central administration 'taxes' on commissioned research and consultancy may make small projects financially unattractive.

It is widely acknowledged that the current administrative processes and procedures for ARC Linkage grants discourage collaboration due to very extended time lags between application and approval, which has led to interest in a 'rolling' application process. There is also a view within industry that university research services should be provided for free, or at minimal cost[52].

Government and business should work with universities to develop and re-engineer business processes, and realign policies to facilitate greater collaboration. It is also important that consultancy is encouraged, and consultancy income is more highly placed in performance and impact metrics, as it is a key indicator of engagement. Nor should these metrics be confined to narrow quantitative indicators such as patents, but they should also encompass qualitative case study material for a more comprehensive picture of engagement.

There are numerous studies and consultants reports about how to improve university-business relationships. The real challenge for business, universities and government is to establish conditions that are favourable for collaborative innovation through *longer-term engagement and partnerships* in a 'business to business' strategic and joint venture environment[53]. This will require each sector understanding the business of the other, and building high levels of trust[54].

It must also be acknowledged that much of the research being undertaken in universities might be of little interest to Australian businesses that have a small commitment to R&D, or to small businesses interested in accessing readily adoptable research 'products'. At the same time however, undergraduate and graduate students working with business through specific projects, work experience, or internships often meet many of the less challenging but still important research assignments for Australian businesses.

Student engagement with industry is an important way of preparing students, including research students, for careers in business and the professions, and should be encouraged. Universities Australia and peak industry organisations have developed a strategy to support this[55].

The vocational education and training sector (VET)

The VET sector has been largely excluded from innovation policy considerations, notwithstanding its key role in the training of STEM workers in a range of technical professions and occupations[56]. The Australian VET system is just one of a few in the world where a trainee is assessed by his or her acquisition of *competencies* relevant to a field of skilled specialisation.

Box 10: The role of Vocational Education and Training in Innovation Policy

The innovation studies literature has established the central role of the vocational education and training (VET) system and VET-trained workers in technology generation, diffusion and incremental innovation. Research has also established that the pattern of innovation in Australia, compared with that in many other OECD countries, makes firms more reliant on VET skills to implement innovation.

Despite this recognition in the innovation literature, the Australian VET system is largely excluded from government innovation policy and programmes in Australia. Evidence for this exclusion is derived from a textual analysis of the principal Australian government policy statements and government-sponsored studies of the Australian innovation system, and from an analysis of the interest groups represented on government innovation advisory and policy structures.

Toner, P., & Dalitz, R. (2014). Vocational Education and Training: the 'terra incognita' of Innovation Policy. Prometheus. Critical Studies in Innovation, 30(4), 411-426. http://researchdirect.uws.edu.au/islandora/object/uws:14008.

This is in contrast to the situation in Europe where technology institutes and polytechnics have a have a significant interaction with industry and are recognised as key institutions in the innovation system.

[52] Some commentators have argued that business has already 'paid' for industry research through taxes and public funding.
[53] The recently completed Dowling Review of Business University Research Collaborations concluded: 'Strong, trusting relationships between people in business and academia form the foundation for successful collaboration'. Dowling, (2015)
[54] Significant contributions from MIT on building better university-business relationships include: Wright, (2008); and Pertuze, Calder, Greitzer, & Lucas, (2010)
[55] See Universities Australia, ACCI, AiGroup, Business Council of Australia, & Australian Collaborative Education Network, (2014)
[56] Toner & Dalitz, (2014)

Australian TAFEs tend to have very strong industry interfaces, and in addition to delivering national industry training packages, they offer a range of 'be-spoke' training courses and advice in specific areas of technology.

Analysis undertaken by the Mitchell Institute indicates that over the period 2003-04 to 2013-14 there has been a much lower rate of growth in VET spending as the other education sectors have grown substantially. Expenditure on VET in 2013-14 was $6.3 billion ($6.0 billion in 2003-04), compared with $23.5 billion for higher education in 2013-14 ($16.5 billion in 2003-04)[57]. The Mitchell Institute Report concludes with the observation:

> There are currently major debates about funding in each of the sectors of Australian education and training, but there is little consideration of the pattern of expenditure between the sectors and how collectively they can best meet our future population requirements and workforce needs. Education funding in Australia needs to be coherent and integrated, rather than the current ad hoc and piecemeal approach.

The impact of the defunding of the VET sector by the States and Territories has had, and will continue to have, a major impact on the capacity of tertiary education system to train people with the vocational skills to meet workplace needs – particularly in the area of STEM skills.

Government research agencies

Funding overview

In 2015-16 the Australian Government will spend $1.8 billion on 'intramural' (internal) research activities. Estimates drawn from the Australian Government's 2015-16 Science, Research and Innovation Budget Tables[58] are reproduced in Table 4.

Table 4: Commonwealth Government expenditure on Intramural research ($m)

Activity	Estimated Actual 2014-15	Budget Estimate 2015-16	Distribution (%)
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	745.3	749.7	41.5%
Defence Science and Technology Organisation (DSTO)	416.5	431.6	23.9%
Australian Nuclear Science & Technology Organisation (ANSTO)	253.9	192.6	10.7%
Geoscience Australia	126.8	121.3	6.7%
Australian Centre for International Agricultural Research	101.1	100.1	5.5%
Antarctic Division	94.8	93.9	5.2%
Australian Institute of Marine Science (AIMS)	38.8	40.5	2.2%
Bureau of Meteorology Research Activities	26.8	26.6	1.5%
Supervising Scientist	14.7	15.4	0.9%
Australian Astronomical Observatory	11.8	11.9	0.7%
Other	27.2	22.0	1.2%
Total Australian Government research activities	1,857.5	1,805.5	100.0%

Source: Department of Industry Innovation and Science. "Science, Research and Innovation Budget Tables." Canberra: Department of Industry Innovation and Science, 2015.

The extent to which this investment is coordinated, the level of collaboration in priority setting and resource allocation, and the extent to which research outcomes are being effectively translated for economic and social benefit is a matter of concern.

CSIRO

CSIRO is Australia's leading organisation for scientific and industrial research. Over the years CSIRO has developed a strong focus on applied industry research, as well as a commitment to basic or fundamental research, particularly in the fields of agricultural sciences, plant and animal science, the environment and ecology and geosciences.

There is a view that basic research should be undertaken in the university sector and the CSIRO should develop closer linkages with it. Under new leadership, CSIRO aims to shift the balance towards 'translational' and industry-driven research, and become Australia's 'digital innovation

[57] Noonan, Burke, Wade, & Pilcher, (2015)
[58] Department of Industry Innovation and Science, (2015)

powerhouse'[59]. In July 2015 CSIRO launched *Australia's Innovation Catalyst: CSIRO Strategy 2020*. The four key elements of the Strategy are listed in Box 11.

Box 11: Australia's Innovation Catalyst: CSIRO Strategy 2020

Australia's Innovation Catalyst: CSIRO Strategy 2020

Customer first: Create deeper innovation relationships with our customers and prioritise the highest value investments

Global outlook, national benefit: Deliver connectivity to the global science, technology and innovation frontier as well as access new markets for Australian innovation

Collaboration hub: Integrate the best solutions for our customers, increase our flexibility and enhance Australia's innovation performance

Breakthrough innovation: Increase our capacity to help reinvent existing industries and create new industries for Australia and deliver public good

CSIRO's 2020 Strategy is a major departure from the way the organisation has operated in the past, with a much bigger focus than in the past on entrepreneurial start-ups and the commercial outcomes of research, and represents a major commitment to Australia's innovation future. Other organisations also play a key role in the innovation system, including the Defence Science and Technology (DST), which converts smart ideas into defence capability.

Multi-sector research activity

The Australian Government provides science, research and innovation support for activities that span universities, government research agencies, medical research institutes, rural research development corporations and some other agencies. The main 'multi-sector' research funding categories are listed in Table 5.

Table 5: Commonwealth Government expenditure on multi-sector research ($m)

Programme / Activity	Estimated Actual 2014-15	Budget Estimate 2015-16	Distribution (%)
Cooperative Research Centres Programme	146.1	146.7	7.6%
National Collaborative Research Infrastructure Strategy	100.1	150.0	7.8%
NHMRC Research Grants	930.1	845.8	44.0%
Medical Research Future Fund	0.0	10.0	0.5%
ICT Centre of Excellence*	21.4	21.0	1.1%
Australian Renewable Energy Agency	267.3	196.9	10.2%
Carbon Capture and Storage (CCS) Flagships	61.1	58.0	3.0%
National Low Emissions Coal Initiative	31.631	16.9	0.9%
Low Emissions Technology Demonstration Fund	0.0	40.0	2.1%
National Environmental Science Programme	8.6	21.5	1.1%
Office of Water Science	19.6	19.5	1.0%
Grains	68.2	69.1	3.6%
Meat Research	54.9	54.0	2.8%
Horticulture Research	42.5	42.5	2.2%
Dairy Australia Limited	20.9	22.3	1.2%
Fishing Industry Research	17.4	18.1	0.9%
Rural Industries R&D Corporation	13.	12.2	0.6%
Wool Research	12.3	11.5	0.6%
A Competitive Agriculture Sector - boosting farm profits through rural R&D	19.3	29.2	1.5%
Other Rural Research	24.1	22.6	1.2%
Other	238.4	114.6	6.0%
	2097.0	1922.4	100.0%

Source: Department of Industry Innovation and Science. "Science, Research and Innovation Budget Tables." Canberra: Department of Industry Innovation and Science, 2015.
* Since transferred to the CSIRO

There are concerns about the extent of coordination of research effort across agencies, collaboration, and the extent to which this allocation represents the best use of available resources to achieve research and innovation outcomes.

Industry and business

Many submissions to the Inquiry noted that the problems with Australia's innovation system are not so much on the supply-side, but on the *'demand-side'*. It is argued by many that Australian companies

[59] CSIRO, (2015)

lack the incentives to invest in R&D, to diffuse and adopt new technologies and skills, and to engage with the public research system, or even other businesses, to drive innovation and business growth.

Measures to encourage business innovation

The current assistance and incentive measures for business identified in the Science, Research and Innovation Budget Tables are set out in Table 6. These tend to concentrate on the *supply, or production*, side of business growth. Expenditure is concentrated in the R&D Tax Incentives area, which makes up 92 per cent of the expenditure. The recently reconfigured Entrepreneurs Programme makes up only 1.2 per cent of the expenditure.

Table 6: Commonwealth expenditure on extramural science, research and innovation ($m)

Programme / Activity	Estimated Actual 2014-15	Budget Estimate 2015-16	Distribution (%)
R&D Tax Incentives - Non Refundable	980.0	960.0	30.4%
R&D Tax Incentives - Refundable	2,040.0	1,969.0	62.3%
R&D Refundable Tax Offset	-50.0	-25.0	-0.8%
Automotive Transformation Scheme	169.5	152.6	4.8%
Entrepreneurs' Programme - Commercialising Ideas	4.3	35.6	1.1%
Entrepreneurs' Programme - Research Connections	0.2	2.8	0.1%
Commercialisation Australia	40.9	7.0	0.2%
Enterprise Connect	1.7	0.6	0.0%
Industry Growth Centres Initiative- Commercialisation Fund	1.0	12.0	0.4%
Industry Growth centres Initiative- Project Fund	0.0	7.0	0.2%
Innovation Investment Fund including Innovation Investment Follow-on Fund	29.7	34.7	1.1%
Establishment of an ICT-enabled Research Laboratory - Commonwealth Assistance	6.7	2.7	0.1%
Clean Technology Innovation Programme	7.5	1.7	0.1%
Other	1.8	0.5	0.0%
	3,233.3	3,161.1	100.0%

Source: Department of Industry Innovation and Science. "Science, Research and Innovation Budget Tables." Canberra: Department of Industry Innovation and Science, 2015.

The information in Table 6 does not include Australian Trade Commission (Austrade) expenditure, which focuses on international market development. In 2015-16 Austrade expenditure is estimated to amount to $377.8m ($344.6m in 2014-15). This commitment, which amounts to 12 per cent of the identified science, research and innovation expenditure, is a significant omission from the Budget tables in Table 6 and under-represents the Government's innovation commitment[60].

The *R&D tax incentive* is a major form of government support for business innovation. The distribution of the incentive among industry sectors is set out in Table 7.

Table 7: Distribution of the R&D tax incentive among industry sectors ($m)

Programme / Activity	Estimated Actual 2014-15	Budget Estimate 2015-16	Distribution (%)
Agriculture	72.9	74.2	2.6%
Defence	38.4	31.2	1.1%
Energy	380.6	374.3	12.9%
Environment	110.8	36.2	1.2%
Health	85.7	89.3	3.1%
Industrial production and technology	1271.1	1448.9	49.9%
Political and social systems, structures and processes	519.9	616.1	21.2%
Transport, telecommunications and other infrastructures	349.4	217.5	7.5%
Other	141.3	16.3	0.5%
Total Industry R&D Tax Measures	2,970.0	2,904.0	100.00%

Source: Department of Industry Innovation and Science. "Science, Research and Innovation Budget Tables." Canberra: Department of Industry Innovation and Science, 2015.

[60] One of Austrade's two reported outcomes is to 'contribute to Australia's economic prosperity by promoting Australia's export and other international economic interests through the provision of information, advice, and services to businesses, associations, education institutions and governments'. See Australian Trade Commission (Austrade), (2015)

Almost 92 per cent of Australian Government Budget assistance for private sector science, research and innovation is provided through the R&D tax incentive. While the incentive is widely supported within some industry sectors, it remains unclear whether the incentive is the best way to allocate very limited resources to industry to support innovation.

Data on business collaboration with universities

Data included in the 2012 Excellence in Research Australia (ERA) Report provides some insight into the areas where Australian businesses are working with universities. Using information from the Higher Education Research Data Collection (HERDC), the ERA Report indicates that a total of $1.59 billion was received from industry and other related sources over the three years 2008-2010. Of this:

- A total of 44 per cent of industry research income ($699.8m) was in the medical and health sciences research field. The predominant research disciplines are clinical science, immunology, neurosciences, oncology and carcinogenesis, paediatrics, reproductive, pharmacology and pharmaceutical, and public health
- Biological sciences funding totalled $150.4m (9.5 per cent of total funding). The predominant disciplines are biochemistry and cell biology, genetics, ecology
- Funding for engineering amounted to $220.1m (13.9 per cent)
- Other fields that received some support were Agricultural and veterinary sciences (3.8 per cent of total funding), Earth sciences (3.6), Environmental sciences (3.6), Studies in human society (2.8), Education (2.7), Chemical sciences (2.3), and Commerce, management and tourism (2.1).

The concentration of funding in the medical and health sciences reflects the strong and continuous investments over many decades in basic, or fundamental research through the NHMRC, State governments, philanthropy and other sources. It has built up a world-class capability that is of interest to the health and medical industry[61]. In addition, a new medical research fund was established in the 2014-15 Commonwealth budget. The Australian health industry has benefitted substantially from the high concentration of university research in health.

Aggregate ABS data show that Australian businesses do not report significant activity in collaborative innovation arrangements with clients, suppliers or public research organisations. Australian firms rank poorly for the fraction of R&D active firms in manufacturing and in services.

Small and medium business

A great deal of attention in current discussion has been given to the role of SMEs in the innovation system, and the relatively low levels of interaction with the research sector. The Commonwealth and most States/Territories have introduced measures to facilitate business and research connections within their jurisdictions, including technology vouchers and research connections programmes.

Industry itself, through peak industry and sectoral organisations and professional associations, has a role in establishing business collaboration through supporting business networks within and between regions. Australian Business Limited (ABL) and the Australian Industry Group (AiG) have well developed programmes in this area[62].

The Department of Defence has committed to building capability in industry through the Industry Skilling Program Enhancement (ISPE) package. ISPE aims to expand the pool of skilled workers from which defence industry can recruit, enhance work and career pathways and address specific skills gaps in defence industry capability. ISPE initiatives include the Defence Engineering Internship Program (DEIP), a Masters programme in systems support engineering, a Schools Pathway Programme and sponsorship of the Re-Engineering Australia Foundation[63].

[61] This support has had the imprimatur of inquiries and reviews of medical research including McKeon et al., (2013) And Australia. Health and Medical Strategic Review, (1999)
[62] It is the case that not all SMEs are members of business associations, or take the time to join.
[63] See more at:
http://www.defence.gov.au/dmo/DoingBusiness/Industry/SkillingDefenceIndustry/IndustrySkillingProgramEnhancement/#sthash.qVVpCm97.dpuf

The US Small Business Innovation and Research (SBIR) program, allocates a proportion of public research expenditures to encourage SMEs to apply research outcomes. It has grown to be a significant source of 'venture' investment. South Australia and Queensland have introduced SBIR type schemes.

Submissions to the Inquiry advocated a more active role for public procurement in supporting innovation. Submissions also indicated that current guidelines and application of 'value for money' and probity criteria limited opportunities to lodge innovative solutions[64].

Taxation policy

There is currently a great deal of discussion and submission activity around taxation measures to support innovation, particularly in the context of the Treasury Tax White Paper Taskforce[65] and the Government's renewed interest in innovation. Discussions canvass a range of areas, depending on positions in the overall taxation system. These include:

- R&D tax incentives, including special treatment for SMEs/ research collaboration
- Capital gains taxes and 'patent box' arrangements
- Venture capital limited partnerships
- Accelerated depreciation provisions
- Employee share schemes
- Negative gearing, which can divert capital into property investment
- Rates of company tax, which impact on incentives to invest
- Rates of personal income tax, which impact on incentives to work
- State based stamp duties, transactions taxes and payroll taxes

Submissions to the Inquiry sought changes to the R&D tax incentive, CGT and the tax treatment of venture capital investment and returns. Submissions pointed to Australia's relatively high rate of *company tax* being a major inhibitor of investment in innovation, and some have suggested a reduced rate for export-oriented manufacturing. There is also a view that Australian companies are risk averse, and corporate boards very conservative, with share market analysts and fund managers preferring to see a regular flow of dividends rather than a commitment to investment in innovation.

A recent RBA report suggests that the lack of investment in non-mining sectors is due to private firms imposing a very high hurdle rate of return on future investments. Accelerated deprecation provisions that are features of the tax regime from time to time, can lift the ROI on some investment projects. High tax rates also encourage owner/managers of private companies and non-incorporated businesses to put profits into their superannuation funds, which tend to purchase secure assets, such as property, rather than invest in growing the business.

It is important to ensure that taxation reform aligns with generally accepted tax principles, contributes to innovation and productivity outcomes, and above all, ensure that measures implemented are stable, transparent and accountable.

Concluding comment

This Part of the Report has drawn attention to the diverse nature of the Australian innovation system, and identified issues from the perspectives of research organisations, industry and government. It has pointed to areas of concern and weaknesses which would need to be addressed to achieve the necessary step changes in innovation system performance, and hence to lift productivity, international competiveness and living standards into the future.

These issues form the basis for recommendations in Part II of this Report across five critical areas: System leadership, strategy and evidence based policy; Enterprise innovation capacity and capability; Investment in science, research and innovation; Local and regional innovation ecosystems; and Education and training infrastructure.

[64] In 2013-14 Australian SMEs secured 34.4 per cent by value ($16.8 billion) of Commonwealth procurement contracts and 55.2 per cent of the number (36,487). http://www.finance.gov.au/procurement/statistics-on-commonwealth-purchasing-contracts/

[65] The Taskforce has received over 870 formal submissions and has held over 120 consultation meetings. See http://bettertax.gov.au/ and The Treasury, (2015)

PART II: FINDINGS AND RECOMMENDATIONS

Framework for Australia's Innovation Future

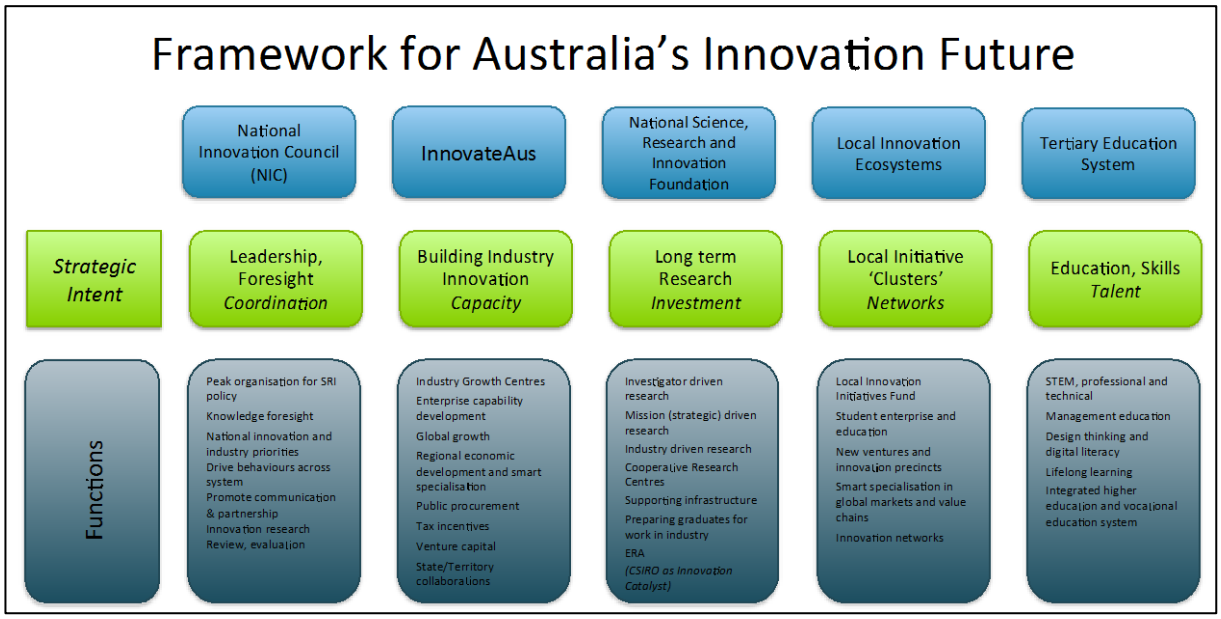
Australia's innovation system requires realignment to improve productivity, competitiveness, employment and well-being, and to prepare for the future. This new approach will involve clear leadership and priority setting, innovation measures and interventions that are built to last, a strategic, long-term approach to investment in science and research, recognition of the critical role of local innovation ecosystems, and an education and training system that is fit for purpose.

Australia's innovation future can be secured by actions across five Strategic Action Areas (SSAs):

- Establish a *National Innovation Council* to provide leadership and set priorities
- Build industry and enterprise capacity through an innovation agency, *InnovateAUS*
- Establish a high level *National Science, Research and Innovation Foundation (NSRIF)* to guide investment in fundamental, strategic and industry research
- Support local innovation ecosystems through a *Local Initiatives Innovation Fund*
- Develop knowledge and skills through an *Integrated Tertiary Education System*

These Strategic Action Areas (Figure 2) are intended to deliver a comprehensive and connected approach to innovation, but with each action area having a clear role in the innovation system. The action areas are detailed in this Part of the Report.

Figure 2: Framework for the Australia's Innovation Future



Strategic Action Area 1: Develop a comprehensive basis for innovation policy through the establishment of a National Innovation Council

A National Innovation Council (NIC) should be established as the peak organisation for science, technology and innovation policy – a body that engages with all key stakeholders to undertake knowledge foresights, set priorities, draft action plans, improve innovation system performance, and develop early responses to challenges and opportunities in a global competitive environment. The NIC would replace the current Science Council.

It is recommended that:

Government take action to establish a *National Innovation Council* (NIC) with a role to develop and advise on national innovation policy. The NIC would undertake a regular knowledge foresight exercise, set national innovation and industry development priorities and promote active communication, cooperation and partnership across sectors and agencies. The Prime Minister would chair the Council.

The National Innovation Council

The NIC would have a national role to:

- Set national innovation and industry development priorities on the basis of foresight outcomes, including the designation and review of *Industry Growth Centres*
- Coordinate and align the activities of the proposed business development agency *InnovateAUS,* and the proposed *National Science, Research & Innovation Fund*
- Promote active communication, cooperation, and partnership across sectors and agencies with a focus on business-university collaboration
- Develop a joined up approach to international engagement, including connections with international research and innovation bodies
- Drive attitudinal and behavioural change towards science, research and innovation across the national innovation system
- Promote a national culture of entrepreneurship.

Regular *knowledge foresighting* exercises would address challenges and implications for Australia's national innovation system. There are several models to explore including Sweden, Finland, Ireland, Singapore and, most recently, the US with its deeply researched Advanced Manufacturing Partnership initiative.

As in business, foresight in the innovation context is about identifying current and future areas of competitive advantage, distinctiveness and capability where Australia can most productively focus its efforts. In Europe, this approach has led to a strategy of 'smart specialisation', which has provided a roadmap for repositioning economies and industries in the wake of the global financial crisis.

The Prime Minister would Chair the Council, with the Secretariat located in the Prime Minister's Department. The Council would have a 'hands-on' focus, drawing membership with direct involvement in government, business, research and education, the not-for-profit sector and workplace relations.

Members would be drawn from:

- Ministers for Industry, Innovation and Science, Education, Health, Environment, Trade, and Agriculture
- Chief Scientist, Chief Defence Scientist, Chief Economist (as CEO of the National Bureau for Innovation Research - see below)
- CEOs of Research funding councils – NHMRC, Australian Research (and Innovation) Council and the larger RDCs (GRDC, MLA and HIA)
- CSIRO
- University Vice-Chancellors
- Business CEOs from key industry sectors
- Industry Growth Centre leaders

- CEOs from within the NGO sector
- Industrial and Workplace Relations leaders

The NIC would be constituted as a body corporate under its own legislation, responsible to the Prime Minister. It would maintain close connections with State/Territory Ministers for Industry, Innovation and Education and Chief Scientists or equivalent. NIC would regularly review and evaluate the effectiveness the national innovation system in achieving innovation outcomes. It would look at measures that build interaction among the actors and processes within the system and improve agility, flexibility and responsiveness. Over the past 15 years such agility has been elusive.

Science, Research and Innovation Committee of Cabinet

As indicated on page 14 there are many Ministers involved in issues relating to innovation. There is a strong case for a Committee of Cabinet to ensure that innovation policy issues are addressed in a holistic, cross-portfolio, framework.

A Science, Research and Innovation Committee of Cabinet should be formed to drive Australia's Innovation Future and to ensure that policy initiatives are addressed in a cross-portfolio and whole of government manner.

The Prime Minister, and the Ministers for Industry, Innovation and Science, Education, Agriculture, Health, Environment, and Trade would be core members of the Committee.

Information about research impact and engagement

Among its various roles, the NIC would be the key body for developing a standardised information system on research output, impact, and engagement that includes public research organisations, universities and medical research institutes. There are, of course, many dimensions for assessing and reporting on impact, including:

- Increasing competition for funds in the research budget
- Interest for the economy and society in demonstrating the value of research
- Types of impact – peer, commercial, social, environmental, cultural
- Diversity of outcomes from the range of research disciplines
- The need to report cost effectively.

Over the last 10 years numerous reports, papers, and documents have been prepared on research impact. Recent contributions in an Australian context include a trial conducted by the Group of Eight and Australian Technology Network universities on research impact. The trial has used a selection of case studies and narratives, prepared and submitted by the universities and assessed by expert review panels.[66] More recently, ATSE made a proposal for an 'Impact and Engagement for Australia' metric to be determined in parallel with the current Excellence in Research for Australia (ERA) exercise[67].

Since 2000 the Government has published the *National Survey of Research Commercialisation*[68]. The survey collects data from universities, publicly funded research organisations, CRCs and medical research institutes in relation to intellectual property activity, start-up company activity, research contracts, consultancy and direct sales, skills development for knowledge exchange and resources for research commercialisation. A review of the Survey in 2015 recommended broadening the scope of the survey to include questions on industry engagement[69].

It must be acknowledged that there is no consensus on the best mix of metrics to evaluate research activities, but has the view that impact measures must stand the test of credibility and assist government in policy-making, universities and researchers in determining priorities and business in building engagement with the research sector. This implies a mix of quantitative and qualitative indicators, including case studies that promote both achievement and behavioural change.

[66] Group of Eight Universities & Universities, (2012) The Rand Corporation reviewed the methodology. See Jones, Castle-Clarke, Manville, Gunashekar, & Grant, (2013)
[67] Gray et al., (2015)
[68] See http://www.industry.gov.au/innovation/reportsandstudies/NSRC/Pages/2014-National-Survey-of-Research-Commercialisation.aspx
[69] Department of Industry and Science, (2015b)

Innovation research

Innovation research is a complex, multidisciplinary and rapidly expanding international research endeavour. Many of the models of innovation policy impact and business innovation are out of date or lack a strong evidence base. There is a need to better inform policy and national debates through a much more sophisticated approach to what has become one of the most important but not well understood areas of knowledge creation.

A major commitment is being made to economic research relating to innovation through the Office of the Chief Economist in the Department of Industry, Innovation and Science. The work of the Office will be important in providing the knowledge and evidence base for the work of the NIC. The Office already assists in our understanding of the innovation system through annual publication of the *Australian Innovation System Report*[70] and regular updates throughout the year. It also publishes research papers that provide valuable information on innovation system characteristics and performance[71].

The research programme of the Office of the Chief Economist should be continued and extended as a National Bureau of Innovation Research (NBIR) under guidance from the NIC. The Bureau would be tasked to provide an evidence base for national issues such as changes in income tax and capital gains tax measures to support the innovation system. The Bureau might also be responsible for preparing and publishing the metrics of research impact.

The Bureau would be advised by a reference group that brought business, economic and community perspectives on innovation. It would be mindful of gender imbalances in many parts of the innovation system and monitor progress towards diversity in conjunction with other relevant agencies, such as the Workplace Gender Equality Agency.

Further, there is a serious absence of capacity for independent, objective innovation system research external to government but within the research sector. There are a relatively small number of accomplished researchers engaged in innovation inquiry and consulting, but an absence of critical mass, incentive for collaboration and building capability. Like any area of policy it is important that policy development be evidence based, as well as being aligned with international developments in theoretical understanding of innovation policy and performance.

A *National Institute for Innovation Policy and Performance* (NIPP) should be established as a consortium across university business schools and innovation centres with researchers invited to join on the basis of the current and potential contribution to the creation and application of knowledge about Australia's innovation system. Most advanced countries have major centres of innovation studies such as Sussex, Manchester and Imperial in the UK, MERIT in the Netherlands and Stanford and MIT in the US.

A one-day annual *National Innovation Forum* could be held to inform, advise and receive feedback on the performance, achievements and gaps in the innovation system. It would target industry, research organisations and government. The Forum would be modelled on the very successful ABARE outlook conference. It would operate on a continuing basis throughout the year via policy and researcher networks and social media.

[70] See Department of Industry, (2014)
[71] See http://www.industry.gov.au/Office-of-the-Chief-Economist/Research-Papers/Pages/default.aspx

Strategic Action Area 2: Build enterprise capability and collaboration through a new industry-facing innovation agency

There is an urgent need for stability, consistency and a strategic approach to building innovation capability in Australian firms for growth, competitiveness and participation in global value chains, and to promote collaboration within and between industry and the research sector. This approach should consolidate the business facing activities of government in a single body while reflecting the critical role of the public research system.

It is recommended that:

> **Government take action to establish an independent agency, *InnovateAUS*, to build enterprise capability and promote collaboration through a targeted programme portfolio of: Enterprise capability; Global growth; Industry clustering; and Public procurement. InnovateAUS would develop, implement and review policy in relation to taxation and R&D incentives, procurement, and venture capital.**

Many submissions to the Inquiry made reference to overseas agencies, such as InnovateUK, Finland's Tekes and Enterprise Ireland, as possible models. Brief profiles of these agencies are located in Attachment 3. An Australian agency should draw on these experiences and, in addition, reflect the unique characteristics of Australia's federal system of government and public administration in a new model of cooperation. As with all aspects of the innovation system, InnovateAUS would have a strong international focus.

Mission and purpose

InnovateAUS would be responsible for the development and growth of Australian enterprises in world markets. It would work in partnership with businesses to help them start, grow, innovate and win export sales in global markets. It would develop a suite of programmes to bring together, and add to, existing business improvement, export promotion and research translation programmes in a strategic framework to:

- Open up enterprises to relevant advances in technology, market intelligence, changing customer behaviours and expectations, potential disruptions and foresighting. This would include knowledge sharing and problem solving with other organisations and ecosystems.
- Build the 'absorptive capacity' of enterprises, i.e. the ability to identify, assimilate and capitalise on new information, to learn and to respond in an agile fashion to emerging opportunities. An important element is growing the skills and capabilities of workforces, entrepreneurs and managers.
- Encourage firms to internationalise and diversify and to grow in global markets, either directly or through participation in global value chains. This expertise may be developed through physical proximity in local clusters as well as broader connections through virtual networks.
- Support collaborative research and development and business development activity between firms, research organisations and industry, with a view to continual innovation, technology diffusion and transformation of current business models and practices.

Strategies should provide a mix of incentives including targeted measures aimed at building capacity and capability in individual businesses, and broader incentive measures that have wider eligibility. There are trade offs to be considered between targeted and broad based measures: targeted measures can be effective in delivering outcomes, but they can be expensive to administer; broad based measures, such as tax incentives, can be more efficient in distributing support, but less effective in reaching businesses considered to be most in need of assistance.

InnovateAUS would have a *sectoral focus*, developed around the Industry Growth Centres (IGCs) and agreed through the National Innovation Council. IGCs aim to lift competitiveness and productivity by focusing on areas of competitive strength 'to help Australia transition into smart, high value and export focused industries'[72]. The current IGCs are: Advanced Manufacturing, Food and Agribusiness,

[72] The Industry Growth Centres Initiative, announced in early 2015, is the centrepiece of the Commonwealth Government's new industry policy direction and part of the Industry Innovation and Competitiveness Agenda. See Department of Industry and Science, (2015a)

Medical Technologies and Pharmaceuticals, Mining Equipment, Technology and Services, and Oil, Gas and Energy Resources. These would be central to the InnovateAUS delivery strategy.

Programmes and measures

InnovateAUS programmes should be designed around strategic outcomes, rather than functions. A suggested scope and coverage of programmes is set out below:

- Enterprise capability development
- Global growth and supply chain opportunities
- Regional economic development 'clusters' and smart specialisation
- Public procurement for technology innovation
- Income contingent loans for growth enterprises
- An efficient and effective system of R&D taxation incentives
- Support for early stage venture capital investors

Innovation programmes must be focussed and targeted on outcomes and clearly resonate with fundamental businesses objectives that relate to the creation and maintenance of customers. Existing programmes, including the DIIS Entrepreneurs Programme and Austrade Trade Development programmes, should be realigned and integrated to provide a greater focus on results. By linking DIIS and Austrade initiatives, InnovateAUS would have a strong international focus.

Programme design should reflect learning from successes and failures of earlier initiatives, and be based on sound policy research and analysis. This is particularly important in the context of a very large number of programme initiatives that have been implemented, reviewed, restructured and terminated over the years since the launch of *Backing Australia's Ability* in 2001[73].

Enterprise capability development

An Enterprise Capability Programme should be implemented with the aim of lifting business productivity, achieving operational excellence, and assisting business transformation – taking advantage of the opportunities provided by digital technologies.

The programme should incorporate and extend the Entrepreneurs Programme *Accelerating Commercialisation* element and introduce new measures.

Measures of support and assistance might cover:

- *Prototyping* new products or improve existing ones with a view to lifting productivity and business profitability. Funding would be provided where the commercialisation of the project is near. The programme would also support pilot testing of projects in terms of design, functionality, scalability, customer feedback, risk profile and potential returns.
- *Workplace innovation* to improve productivity and the quality of working life. Supported projects would: create new, innovative ways to operate including lean manufacturing; support capture of know-how and innovation ideas; be implemented through management-workforce partnerships; and have wide novelty value so that results can be diffused across other organisations. A workplace innovation programme would build on earlier successful initiatives offered by DIIS and predecessor departments.
- *Quality assurance* programmes to assist companies achieve quality certification and 'accredited supplier' schemes. Certification is often required for entry to international markets. Achieving high standards of quality is sometimes a major challenge for fast growing businesses. Such a programme would also seek to instil a 'quality culture' in businesses to ensure that products and services delivered to customers are reliable, consistent, and free from defects.
- *Research projects* to create new capabilities, competencies, and knowledge. The programme would fund collaborations between companies and research organisations where the company is the initiator. The programme would include current features of the Entrepreneurs Programme Research Connections component. Additional, or follow on, funding may be provided to assist in the commercialisation aspects of the programme.

[73] Australia. Prime Minister, (2001)

- *A digital transformation and enabling technologies initiative* to lift the take-up in businesses, particularly small business. The initiative would be an important addition to the current scope of the Entrepreneur's Programme. Digital technologies enable innovation in all aspects of the sourcing, production, sales, and distribution process[74].
- *Collaboration strategies* to take advantage of opportunities at the enterprise level for the creation of new products and services through the intersection of industry sectors, disciplines and technologies, such as intelligent engineering with software, electronics and ICT.

Traditional businesses have embedded knowledge and capabilities that remain important for Australia's innovation future. These include remarkable capacities for ingenuity, intuition and resourcefulness. Many businesses want to transform, but lack the knowledge, capability and access to credible sources of advice to take the risk in investing in a digital future. However, without digital transformation, there is no innovation future.

- *A national management capability development programme*, particularly in SMEs with high growth potential. The programme would have a focus on building knowledge, skills and experience in areas such as: governance and corporate renewal; leadership; the management of innovation; use of management information; marketing and selling, quality processes and systems; collaboration with businesses and research organisations; networks and relationships with customers through global value chains; digital technologies and digital transformation, including use of social media; design thinking and design led innovation.

  This programme would be delivered under contract with a leading Australian business school, or a consortium of schools, possibly with linkages to one or more of the top global business schools and to design and engineering faculties. Merit based scholarships for SME managers and executives to attend executive programmes should be offered.

Global growth and supply chain opportunities

A Global Growth Programme should be implemented that focuses on the internationalisation of SMEs with high growth potential, acknowledging that commitment to international markets requires significant investment in technology, capability and market development.

Several Australian businesses that gave evidence to the Inquiry have been successful in global growth strategies[75]. The Automotive Transformation Programme has been an important initiative and could, after evaluation, be a model for other industries undergoing transformation. Current Austrade programmes also have a focus on global growth:

- The *Export Market Development Grants* (EMDG) scheme, which provides assistance for aspiring and current exporters. The scheme supports a wide range of industry sectors and products, including inbound tourism and the export of IP and know-how outside Australia
- The *Trade Services* scheme, which provides a range of services and assistance to Australian exporters and education providers covering general information and advice on exporting and international business, trade and education alerts, market-entry and expansion assistance and referrals to specialist service providers
- *Austrade TradeStart*, which is an extension to Austrade's own offices and is delivered in partnership with State, Territory and local governments, industry associations and chambers of commerce.

The *Global Growth Programme* would incorporate the Business Evaluation and Business Growth Grants components of the Entrepreneurs Programme with Austrade and other related programmes. It would also incorporate the Entrepreneurs Programme Supply Chain Facilitation Service in its further role of assisting the development of global value chains through:

[74] For example, digital prototyping, information modelling and analytics enable firms to invent, design, build, deliver, and support products and projects faster, better and more efficiently and effectively. They can provide the 'digital thread' that links businesses through global value chains and create efficiency and productivity gains through reduced transactions costs.

[75] For example, Keech Australia Limited (Submission No 17 and *Hansard* 3 August 2015) and Hoffman engineering(H*ansard* 24 August 2015)

- An enhanced *Industry Capability Network (ICN),* which introduces Australian and New Zealand companies to potential projects. Location within the InnovateAUS would ensure effective connections to business development and export market initiatives
- A new *Global Opportunities Scheme,* comparable with those of other countries, which will be established to provide targeted export and investment facilitation services to help companies participate and extend involvement in global supply chains.
- Support for the *Advance network* of Australian senior professionals abroad, which has huge potential to identify and capitalise on opportunities in global supply chains and provide mentoring services to Australian start-ups and SMEs entering new markets (see Box 13).

Box 12: Advance, Australia's global innovation network

Australia's greatest global resource is its diaspora, the one million Australians living and working overseas, as well as the two million who were educated here before returning to their own countries. This global powerhouse, made up of many of our best and brightest, builds and cements our global connectedness, driving innovation and long-term growth.

With over 25,000 high achieving members – 50 per cent women – across 90 countries, Advance is a series of virtual and physical networks and programs that harness this global talent pool to transform our economic prospects. Created with support from the Australian Government, major corporates and donations from members, Advance nurtures links that ultimately bring many Australians home.

The *Advance Innovation Program* has worked with 100 entrepreneurs from early stage start-ups to leverage Advance's global networks. By building entrepreneurial skills, knowledge and connections to Silicon Valley, more than 30 per cent have secured investment back home in Australia. Another program is *elevate61*, a partnership with KPMG Australia, which works with later stage start-ups to build global scale from an Australian base. This includes matching businesses with international advisers, entrepreneurs and investors.

Finally, the annual *Advance Global Australian Awards and Summit* attract next gen game-changers, innovators and well known Australians back home to share insights and know-how, and mentor young Australians. The opportunity exists to scale up Advance and its programs to deliver business and cultural benefits for Australia.

These aspects of the Global Growth Programme would assist SMEs, which lack scale, expertise and access to information, to identify and successfully bid for contracts in global supply chains or major projects internationally. The programme should have the capacity to encourage individual enterprises within a sector to form clusters as a basis for becoming internationally competitive.

The programme would also support young innovative companies in the comprehensive development of their business activities. The aim is to substantially accelerate the global growth of the most promising small enterprises. Young innovative company funding would be directed towards companies that have been in operation for only a few years, and have a proven business concept, so that it already has customers. This would be a new initiative

Regional economic development 'clusters' and smart specialisation

Industry clustering has been acknowledged for many years to have an impact on lifting productivity and promoting international competiveness[76]. Clusters are important for building and sourcing talent, developing technologies, and providing access to scarce infrastructure.

The Commonwealth has invested in building strong linkages with regional communities through the Research and Development Australia (RDA) initiative. RDA is a national network of 55 committees made up of local leaders who work with all levels of government, business and community groups to support the development of their regions. Committees are tasked to:

- Consult and engage with communities
- Promote and participate in regional programs and initiatives
- Provide information and advice on their region to all levels of government
- Support informed regional planning.

RDA committees work closely with Commonwealth officers in the Department of Industry, AusIndustry, and Austrade and have strong linkages with State industry development agencies.

[76] Aranguren & Wilson, (2013; Bresnahan & Gambardella, (2004; Chiesa & Chiaroni, (2005; Cooke & Shvarts, (2007; Innovating Regions in Europe, (2006; Johnston, (2003; Porter, (2005; Potter & Miranda, (2009)

Responsibility for the Regional Development Australia (RDA) should be transferred to InnovateAUS. The current focus of RDA committees would be repositioned to promoting *innovation* on a local a regional basis. This would establish a clear linkage between the Australian innovation system strategies and structures on the one hand and local and regional innovation ecosystems on the other.

InnovateAUS would fund RDAs to undertake smart specialisation projects where the aim is to build regional growth, competitiveness and international engagement. Smart specialisation has emerged among OECD members as a concept and agenda for science, technology and innovation policy in national and regional economies. Strategies have been developed across the European Union and are a condition for Horizon 2020 funding[77].

The smart specialisation approach provides an integrated, place-based and transformation framework that aims to:

- Concentrate public resources on innovation priorities, challenges and needs
- Stimulate industry research, technology and innovation investment
- Build on a region's capabilities, competencies and potential for excellence in a global context
- Foster stakeholder engagement and encourage governance innovation and experimentation
- Ensure evidence-based activities and include sound monitoring and evaluation systems.

InnovateAus should support a *regional innovation training programme* to assist RDAs increase their working knowledge of clusters, SME strategies and regional innovation ecosystems systems in the context of the transition to the new economy – from digitisation to 'factoryless' goods producers.

Public procurement for technology innovation

Innovation outcomes would be boosted by a reorientation of Commonwealth Procurement Policy to encourage SMEs to invest in innovation and technological change. Policy should reflect sophisticated leadership in procurement and be aimed at contributing to the development and spillovers of IP through large, complex and long-running procurements that involve SMEs.

In the United States, the Small Business Innovation Research (SBIR) program was established in 1982, and has been developed as a highly competitive program that encourages domestic small businesses to engage in Federal Research/Research and Development (R/R&D) that has the potential for commercialisation. Through a competitive awards-based program, SBIR enables small businesses to explore their technological potential and provides the incentive to profit from its commercialisation (see Box 14).

The mission of the SBIR program is to support scientific excellence and technological innovation through the investment of Federal research funds in critical American priorities to build a strong national economy. The program's goals are four-fold:

- Stimulate technological innovation.
- Meet Federal research and development needs.
- Foster and encourage participation in innovation and entrepreneurship by socially and economically disadvantaged persons.
- Increase private-sector commercialization of innovations derived from Federal research and development funding.

The overall rationale is that by including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated and the United States gains entrepreneurial spirit as it meets its specific research and development needs.

[77] OECD, (2013). See also http://s3platform.jrc.ec.europa.eu/home

Box 13: SBIR - Competitive Opportunity for Small Business

SBIR targets the entrepreneurial sector because that is where most innovation and innovators thrive. However, the risk and expense of conducting serious R&D efforts are often beyond the means of many small businesses.

By reserving a specific percentage of federal R&D funds for small businesses, SBIR protects the small business and enables it to compete on the same level as larger businesses. SBIR funds the critical start-up and development stages and it encourages the commercialization of the technology, product, or service, which, in turn, stimulates the US economy.

Since its enactment in 1982, the SBIR program has helped thousands of small businesses to compete for federal R&D awards. Their contributions have enhanced the nation's defence, protected the environment, advanced health care, and improved ability to manage information and manipulate data.

https://www.sbir.gov/about/about-sbir

Each Federal agency with an extramural budget for R/R&D in excess of $100,000,000 must participate in the SBIR Program and reserve minimum percentages of their extramural R/R&D budgets for awards to small business concerns for R/R&D. The budget percentages were set at not less than 2.9 per cent for fiscal 2015, increasing to not less than 3.0 per cent in 2016; and not less than 3.2 per cent in 2017 and each fiscal year after[78].

Applying similar criteria, four research agencies, CSIRO, DSTO, ANSTO and Geoscience Australia, would be required to make available a total of $45m for small business research.

A *Small Business Innovation Research* (SBIR) programme should be trialled as a way to realise the growth potential of small, but successful businesses. The programme should be modelled on the successful US SBIR program that encourages domestic small businesses to engage in public R&D that has the potential for commercialisation[79].

An SBIR initiative could enable SMEs to explore their technological potential and provide the incentive to profit from its commercialisation. The programme would include SMEs in the national R&D effort, stimulate high-tech innovation and foster entrepreneurial spirit.

Income contingent loans scheme for growth enterprises

Two prominent Australian academics have proposed a scheme that would help high growth potential SMEs finance innovation[80]. The arrangement involves modest or even zero net imposition on the public purse, and it is very likely to be administratively straightforward. The proposal builds on the successful design and application of income contingent loans in financing arrangements for domestic university students, and emulated now in many other countries (see Box 15).

Box 14: An income contingent loan scheme for Australian innovators

The idea is to link research grants to university teams that have developed their plans in conjunction with industry, and which are designed with profits to the business as a major motivating factor. It is motivated in part by the view that collaboration between university researchers and the private sector has potential to advance the interests of both sectors, and in ways that can be instituted with negligible longer-term budgetary costs.

Projects would be suggested, promoted and explained, and costs estimated, through interactions between university and business partners (in much the same way that ARC Linkage grants currently operate). If successful, projects would involve the provision of financial resources taking the form of grants to finance the university activities and contingent loans for the business partner. Repayment of the loans is a critical aspect of the arrangement.

Businesses benefitting from the research funding would be required to repay some (or even all) of the loan, but only when they are in a viable future situation. This can be ensured by having the obligation depend on future profits, as explained in a similar policy scheme[81]. For example, this could be handled with an additional 2 percentage points being added to company tax, with the amount/proportion of the loan to be recovered set as a policy parameter by government. The transactional efficiency from government collection of debts through the tax system is a major advantage of the scheme.

A further advantage of such arrangements is that they provide insurance to the agents assisted: insurance against repayment difficulties and, critically, insurance against default. If the business is not in a position to repay, no repayment is actually required. Capacity to repay, as with all contingent loans, is the defining characteristic of such schemes.

Applications for support would need to be vetted by the same sort of process now used in the awarding of ARC/NHMRC grants plus the extra element of business assessment too. This joint approach would ensure projects have both university and industry merit and some industry financing is also likely to be required as 'skin in the game'.

The proposal is worthy of serious consideration as a method for supporting business-university collaborations and financing high growth potential businesses.

[78] https://www.sbir.gov/sites/default/files/sbir_pd_with_1-8-14_amendments_2-24-14.pdf
[79] Information abut the US SBIR program is at https://www.sbir.gov/about/about-sbir#
[80] Chapman & Withers, (2015) and Chapman, (2014)
[81] Chapman & Simes, (2006)

Taxation and R&D incentives

Submissions to the Inquiry and recent policy discussions have been equivocal about the value for money of the current R&D taxation incentives scheme. Apart from anecdote, case-by-case narrative, and strong industry lobbying, there is little hard evidence about the effectiveness of the scheme.

The National Bureau of Innovation Research should be tasked to undertake a formal evaluation of the R&D Tax incentive, with a specific reference to identify:

- Ways of increasing its efficiency and effectiveness (value for money)
- Relating it more closely to collaboration with research and education institutions
- Ensuring that the benefit accrues to SMEs and early stage businesses investing in innovation
- Placing a cap on the amount that is paid to individual corporate entities
- Significantly reducing the overall cost to the Budget.

The evaluation should be undertaken on the basis of establishing clear evidence generated through data analysis. It should identify and cost options to achieve intended outcomes, and opportunities for alternative allocations of expenditures where appropriate and justified by the findings. The Bureau has the data analysis skills and capabilities to test relationships and impact. There are also other tax measure proposals which the Bureau might investigate, such as capital gains tax changes and the 'patent box' approach.

Venture capital

Evaluation of the IIF in 2102 concluded that that there is a central role for venture capital and IIF investment in facilitating R&D, innovation and economic growth, and for private equity investments facilitating jobs.[82] New IIFs should be targeted in Industry Growth Centre priority areas with Fund Managers selected on the basis of their knowledge of investing in those areas. InnovateAUS should have a more active role in promoting the innovation opportunities associated with Venture Capital Limited Partnerships (VCLP) and Early Stage Venture Capital Limited Partnerships (ESVCLP).[83]

The *Innovation Investment Fund (IIF*) should be reopened with rule changes envisaged in the evaluation undertaken in 2012.

Governance and funding

InnovateAUS should be formed around the existing statutory framework of *Innovation Australia*, the independent body established under the *Industrial Research and Development Act.* Innovation Australia has an independent board with strong industry orientation. The legislation would be extended to establish InnovateAUS as a statutory agency operating at arms' length from the Department.

InnovateAUS would have a policy development role as well as a programme delivery role, and would not amount to a 'rebadging' of AusIndustry. It would not include the consular, passport and other government services currently performed by Austrade[84]. The CEO of InnovateAUS would report directly to the Minister for Industry, Innovation and Science.

InnovateAUS would require a range of professional specialisations and people with deep industry knowledge. Permanent staffing should be complemented through industry secondment arrangements. Funding should start from a base of current budgets for constituent agencies, with an expectation of increasing the scope and scale of activity over the forward estimates period.

InnovateAUS would also develop partnerships with State and Territory Governments in the development and delivery of State/Territory based innovation initiatives including, but not limited to technology voucher programmes (currently operating in three States), knowledge transfer partnerships

[82] Cumming D and Johan S (2012) Venture's Economic Impact in Australia, December 2012; Department of Industry, Innovation, Science, Research and Tertiary Education (DIISRTE) progress report. See https://www.avcal.com.au/documents/item/619

[83] These roles are currently performed by *Innovation Australia*, previously known as the Industrial Research and Development Board.

[84] Austrade was established by the Australian Trade Commission Act 1985. It is a Prescribed Agency subject to the Financial Management and Accountability Act 1997 and the Public Service Act 1999 and is part of the Foreign Affairs and Trade portfolio. Austrade is responsible to the Minister for Trade and Competitiveness. Austrade operates in 82 offices in 48 markets. Austrade delivered consular, passport and other government services in 172 consular posts, which it manages.

(operating in Queensland), technology development centres and procurement networks, and a range of other measures that build collaborations at the local level.

This cooperation could assist in building a critical mass in enterprise support, as well as avoiding the duplication and overlap that has been a feature of many previous Commonwealth enterprise development programmes where businesses have been able to 'double dip' into different funding pools. This aspect of the programme could involve financial and other support to build scale and scope in current initiatives.

Strategic Action Area 3: Establish a national funding organisation as the investor in Australian science, research and innovation

Despite the strengths in Australia's public research system, connections with business and industry are not sufficiently well developed as a foundation for driving productivity, competitiveness and Australia's long-term innovation future. It should be an aim of government to provide long-term, transparent, predictable and secure funding for science, research and innovation, research training and national and landmark innovation research infrastructure.

Issues

Australia's science and research investment is fragmented and disconnected across multiple agencies and funding sources. It is 'input' oriented rather than focussed on strategic outcomes. The distribution of funding in 2015-16, which represents 43 per cent of expenditure on Science, Research and Innovation, is set out in Table 8. This represents only 0.26 per cent of GDP (estimated at $1.56 trillion).

Table 8: Commonwealth budget allocations for research 2014-15 and 2015-16

Programme / Activity	Estimated Actual 2014-15	Budget Estimate 2015-16	Percentage Distribution
Australian Research Council (ARC)	853.1	789.7	18.9%
NHMRC Research Grants[85]	930.1	845.8	20.3%
National Collaborative Research Infrastructure Strategy	100.1	150.0	3.6%
Sustainable Research Excellence in Universities	185.4	238.7	5.7%
Research Infrastructure Block Grants	239.4	242.2	5.8%
Joint Research Engagement Program	356.1	360.2	8.6%
Research Training Scheme	676.7	649.8	15.6%
Australian Postgraduate Awards	276.1	282.1	6.8%
International Postgraduate Research Scholarship	22.2	22.4	0.5%
National Institutes Program - ANU Component	191.3	192.3	4.6%
Cooperative Research Centres Programme	146.1	146.7	3.5%
Dairy Australia	20.9	22.3	0.5%
Fishing Industry Research	17.4	18.1	0.4%
Grains Research	68.2	69.1	1.7%
Horticulture Research	42.5	42.5	1.0%
Meat Research	54.9	54.0	1.3%
Rural Industries R&D Corporation	13.0	12.2	0.3%
Wool Research	12.3	11.5	0.3%
Other Rural Research	24.1	22.6	0.5%
	4,229.9	4,172.2	100.0%

Source: Department of Industry Innovation and Science. "Science, Research and Innovation Budget Tables." Canberra: Department of Industry Innovation and Science, 2015.

The two main research-funding councils (the Australian Research Council and the National Health and Medical Research Council) allocate only 40.2 per cent of the research funding available through the Budget. The remainder is allocated by the Department of Education and Training, the Department of Industry (for CRCs,) and the Rural Research and Development Corporations.

The assortment of programmes and funding arrangements across Government Departments and Agencies works against the development and implementation of a long term strategy that would support the delivery of a science, research and innovation strategy for Australia's future. Other countries are looking towards achieving greater integration and collaboration in research funding arrangements including the UK, Canada and New Zealand.

Towards an investment framework that supports innovation

Earlier parts of this Report have addressed the need for a step change increase in funding for science and research to underpin innovation, including lifting national R&D investment closer to three per cent of GDP. This would involve a significant increase in government funding – as well as a major commitment by industry.

To ensure that major funding increases are effectively planned and allocated it would be essential to put in place a robust investment framework and decision-making and resource allocation system. Significant funding increases without an overarching investment strategy would be unlikely to achieve

[85] The National Commission of Audit had recommended that the creation of a new national health institutes flagship would combine the National Health and Medical Research Council, Cancer Australia and the research budget of the Australian National Preventative Health Agency. "The new institute would align and fully embed health and medical research in the health system. This would improve patient outcomes and deliver efficiencies by improving the evidence base available to clinicians and patients". National Commision of Audit, (2014)

the greatest possible return on investment. The United States, through the National Science Foundation, and Ireland through Science Foundation Ireland (SFI), provide funding and strategic leadership for national research through an investment model. Summary information is provided in Attachment 4.

It is recommended that

> **A *National Science, Research and Innovation Foundation (NSRIF)* be established as the *investor* in Australian science, research and innovation. The Foundation should undertake a portfolio approach to investment to achieve a balance between excellence, relevance and impact; and between investigator driven, mission (strategically) driven, and industry driven priorities.**

The research investment framework should be developed in a way that achieves national science and research outcomes, enables building critical mass in capability, and supports the delivery of excellence, relevance and impact in those areas of science, technology and innovation deemed to be of high priority for Australia's future as a competitive and dynamic knowledge-based society.

NSRIF should seek to harmonise investments across the Australian Research Council, the National Health & Medical Research Council (NHMRC), the newly established Medical Research Future Fund, Cooperative Research Centres (CRCs), the Rural Development Corporations (RDCs) and Government funded research agencies. The NSRIF should deliver:

- A single, more agile, consistent and responsive approach to funding
- Increased predictability of funding opportunity through a 10-year investment plan, with provision for regular review and update
- An increasing focus on excellence of research and impact for Australia
- A broader focus on engagement and depth of relationships with end-users
- Managing and evaluating the fund as an investment portfolio.

NSRIF should coordinate and prioritise research funding across the public research sector to achieve a critical mass of national research capability. It should allocate funds according to National Innovation Council priorities and develop a balanced portfolio of funding for investigator led, mission led, and industry led research undertaken in the public research sector. *Funds provided through NSRIF to ARC, NHMRC, RDCs, CRCs, CSIRO and other Government Research Agencies and for Research Facilities would be seen as investments in Australia's innovation future.*

NSRIF should encourage arrangements where scientists and researchers are able to submit investment proposals when they reach what they consider to be an 'investable stage', and will not have to wait until money becomes available under annual 'funding rounds'. A 'stage-gate' approach should be encouraged within the Research Councils, where initial proposals are reviewed and researchers invited to further develop and refine proposals. This is a well-established approach for R&D investment and should reduce unnecessary time and cost in proposal preparation. It is likely to lead to better, more focused proposals[86].

NSRIF should operate at arm's length from Government and be constituted under legislation as a non-corporate Commonwealth entity, subject to the provisions of the *Public Governance, Performance and Accountability Act 2013*, within the portfolio of the Minister for Industry, Innovation and Science. There could be scope for achieving efficiencies in corporate and divisional support costs in the funding Councils through standardisation and aggregation of systems and processes. Individual Councils would be able to retain and build brand identity.

Mission and purpose

NSRIF should invest in science, research and innovation that puts Australia at the leading edge of knowledge development and application in industry and society. It should support the best research and create an awareness of the role, impact and opportunities that science and innovation creates. It should also invest in a broader context of innovation that covers the areas of creativity and design led innovation.

[86] The approach is used in the CRC Programme and was followed in the Education Investment Fund.

The overall aim of NSRIF would be to invest for the future and build critical mass and scale in research funding, strengthen collaboration and focus on priorities determined in the National Innovation Council. NSRIF research investments should be grounded in:

- A commitment to revitalising investment in fundamental research to provide the foundation for ongoing developments in the applied sciences and enabling technologies, and in fields that facilitate the translation of knowledge into application and use
- Targeting those areas of research that have the potential to build capability in areas relevant to national innovation and industry development priorities
- Commitment to long-term plans, programmes and budgets for creation and renewal of critical research infrastructure
- Building science, research and innovation capacity in our research organisations through the recruitment and retention of world class scientists and engineers, including social and behavioural scientists
- Supporting translation processes between research organisations and industry through specific programmes and extending opportunities for PhD graduates to work in industry, either directly through recruitment or in partnership.

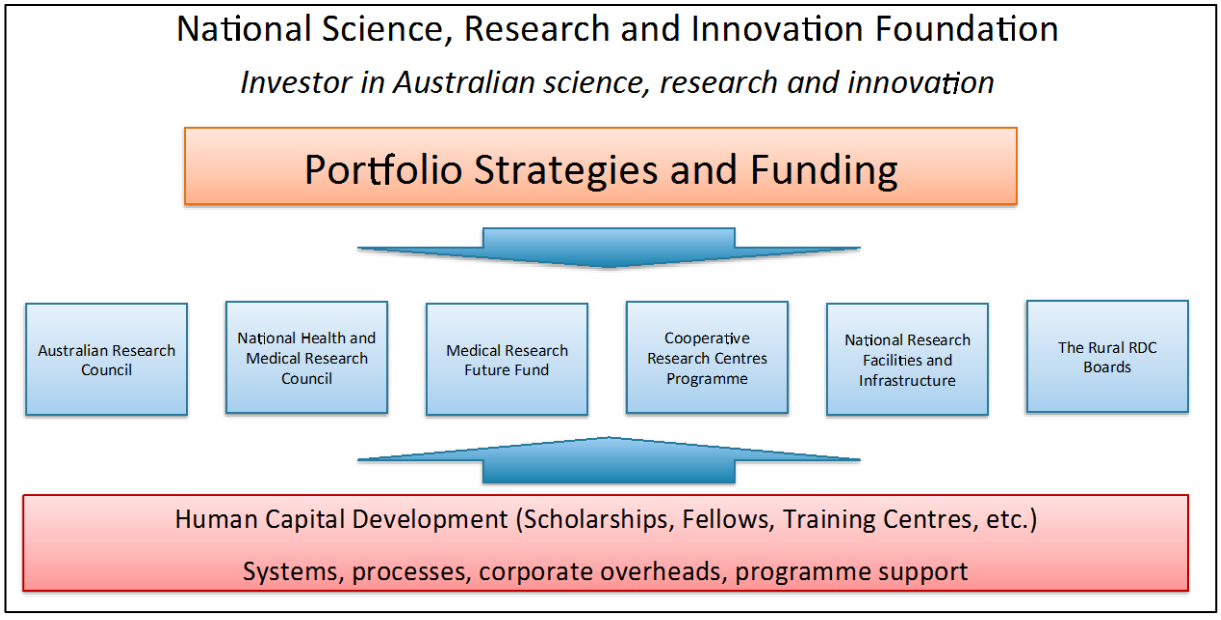
A portfolio approach

Across the science, research and innovation system, NSRIF should seek to achieve a better portfolio of risk, impacts and timeframes. Submissions to the Inquiry and subsequent comments have suggested that too much science investment, across government and industry, is currently focused on low-risk projects with more certain short-term impacts.

NSRIF should allocate funds according to NIC priorities and develop a balanced portfolio of funding for investigator led, mission led, and industry led research undertaken in the public research sector.

The model is depicted in Figure 3.

Figure 3: Proposed National Science, Research and Innovation Foundation

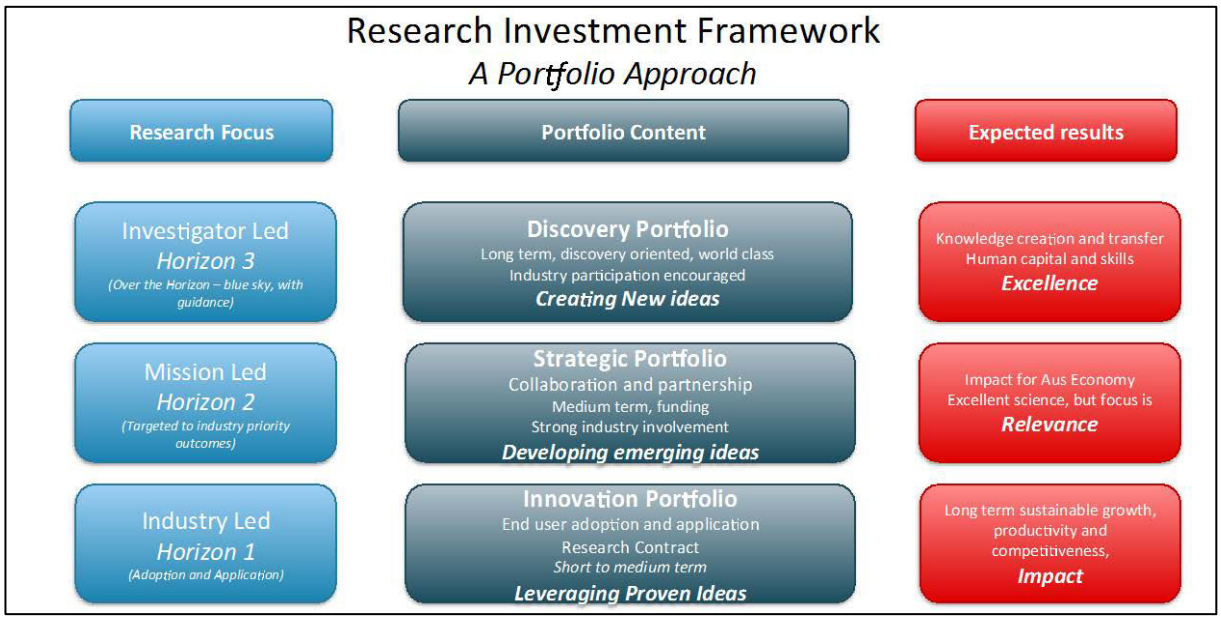


The portfolio would reflect a balance between:

- Investigator driven (discovery) research – to generate new ideas
- Mission driven (strategic) research – to develop emerging ideas
- Industry driven research – to leverage proven ideas

These portfolio elements can also reflect a three-horizon approach, a business concept that is often applied to research investment. A framework is depicted in Figure 4.

Figure 4: A portfolio approach to science, research and innovation investment



Investigator driven research

Through its own investment strategy, the NSRIF would encourage funding Councils to invest in research excellence by supporting:

- *Academic researchers and research teams* in the fields of science, technology, engineering, maths (STEM) and innovation to undertake fundamental research that is most likely to generate new knowledge for the benefit of future generations, and applied research that could be expected to lead to the development of new technologies and strengthen business enterprise performance.

  Science and technology research fields seen to be appropriate to the strategic goals of the NSRIF should be given priority. Cross-disciplinary applicable research should also be encouraged. Current guidelines should be modified to address specific NSRIF objectives.

  NSRIF should fund the full cost of research, relieving universities of the requirement to fund overheads and other costs from other sources.

- Internationally recognised *Centres of Research Excellence* of sufficient scale and duration (at least 10 years) to be leaders in the science and enabling technologies and deliver research outcomes of strategic value to Australia within, but not limited to, the national research priority areas.

  These centres should build critical mass across the research sector and focus on discovery (basic or fundamental) research. Global industry partners should be a key element of the Centres of Research Excellence strategy

  Research Centres should be expected to align with the priorities identified by the NIC. There should be an expectation that Centres of Research Excellence would align with current and additional Industry Growth Centre priorities when established through the foresighting process set out earlier in Action 1.

Centres of Research Excellence should also invest in collaborative *Research Transformation Programmes* with industry where industry requires access to leading edge discovery research[87]. Australian industry participation should be matched by the NSRIF on ratio that provides a real incentive to participate. The most recent developments in Science Foundation Ireland provide a relevant model for this approach.

[87] Global businesses invest in discovery research, including in Australia. The incentives foreshadowed would encourage Australian business to be involved at the edge of science.

Mission driven (strategic) research

Mission-led research should be undertaken towards a particular strategic goal, in terms of expected achievement or results, and in collaboration with industry, through the NIC and the board of NSRIF. Research should be expected to be both excellent and relevant to industry development needs and priorities.

Current ARC programmes that would be included in the mission driven portfolio would include:

- *The Industry Transformation Research Programme*, which aims to ensure that technical projects developed, by collaborating firms and research organisations are complemented and underpinned by broader industrial transformation activities, such as technology diffusion, adaptation and adoption and capability building. Projects should provide research content as well as engagement and outreach activities

  Research Transformation Projects should complement and add scale to projects supported under the Industry Growth Centres Initiative Project Fund[88].

  NSRIF should, under agreement, complement research investments in priority areas identified by State/Territory Governments to assist in building critical mass[89].

- A *Redesigned ARC Linkage Scheme* that meets the strategic objectives of NSRIF and reflects industry circumstances.

  NSRIF Linkage should operate on a continuous funding application basis. This is should be expected to reduce the number of applications, but increase the success rate. Additional administrative funding should, however, be required.

The NSRIF should work with universities and research organisations to streamline the Linkage scheme application process, with a view to reducing the turnaround to no more than 10 weeks.

It would be expected that these programmes would be extended to cover the investment approaches of each of the Councils included within NSRIF. At the same time, the RDCs have had a long term focus on Mission driven research, with the opportunity to share knowledge about better practices in research funding.

In 2011 the Productivity Commission recommended that a new, government-funded RDC, Rural Research Australia (RRA), be created to sponsor broader rural research. With RRA in place, the other RDCs (except for the Fisheries RDC) would be left to focus predominantly on funding research of direct benefit to their industry constituents[90].

Industry driven research

Industry-led research is in many cases applied research. It is generally conducted either within firms or in partnership with public research organisations, such as CSIRO. The practice in European companies, where there is a tendency to invest in strategic research that they see as providing a basis for future products/markets and competitive advantage, should be encouraged

Research is expected to result in measurable benefits to firms and the economy and is focused on the practical development of new materials, products, processes, systems or services. Research also tends to be 'close to market', with an obvious commercial or practical application that can be realised within a timeframe acceptable to commercial investors.

As indicated in earlier parts of this Report, there is an ongoing concern about Australia's record of translation of research to industry, government and the community for economic and social benefit. NSRIF should take a strong interest in the development of measures that should lift performance in this area, but within its overall remit.

In this regard NSRIF should work closely with InnovateAUS in the development and implementation of its research and development programme. It should also develop guidance for industry on ways to

[88] Growth Centres Projects are collaborative projects that build capacity and address barriers impeding competitiveness.
[89] For example, the Victorian Government has established a $200m Future Industries Fund to 'support high growth, high value industries that are critical to Victoria's future as a competitive, innovative, and outward looking economy'. The industries are: Medical technology and pharmaceuticals, New energy technology, Food and fibre, Transport, defence and construction technology, International education, and Professional services
[90] Australia. Productivity Commission, (2011)

work most effectively with research organisations. As indicated above, CSIRO is pursuing a new strategic direction to lead and collaborate in translational research projects and initiatives.

Cooperative Research Centres Programme

In the portfolio framework, the current CRC programme takes an important position between strategic research and innovation. CRCs operate in all areas of interest to NSRIF. CRCs are industry-led collaborations between researchers, industry and the community. The programme is expected to cover the commercialisation of leading-edge research taking place in universities and research institutions[91]. Accordingly, the CRCs, currently funded through the Department of Industry, Innovation and Science, would be recognised as a special category of Industry Transformation Research Centres under NSRIF.

The CRC Programme would be expected to have a close interaction with the Industry Growth Centres Programme by providing research content and transformation capability. As an example of this approach, the industrial transformation programme in the newly established Innovative Manufacturing CRC is summarised below.

Box 11: Innovative Manufacturing CRC: Industry Transformation Program

Innovative Manufacturing CRC: Industry Transformation Program

This program is the economic and industry diversification driver of the IMCRC, aimed at rapid translation of new product and technology opportunities aligned to high growth global value chain opportunities to achieve accelerated industry transformation.

The program will build rich learning and research networks and collaborations, providing an ecosystem of 'increasing returns' in which change becomes progressive and propagates itself in a cumulative way. The program will have a strong (but not exclusive) SME focus, and will drive the elimination or reduction of multi-faceted impediments to adoption of 'innovative manufacturing' characteristics and attributes.

The program:

- Provides indispensable function of accelerated transformation and transition to 'new manufacturing' by addressing multiple impediments to adoption and adaptation of new technologies and innovative business organisation, and ensuring these are aligned to highest growth opportunities in global value chains
- Follows international best practice in combining technological with organisational and strategic innovation, for maximum diffusion and impact, and leveraging demand pull factors
- Provides gateway to all IMCRC programs and ensures integration across programs, by providing clear company pathways, and consolidation of existing cohort of companies and strong recruitment of additional ones
- Leverages and works with portal organisations to maximise company involvement in the IMCRC, and ensure the CRC's strong growth
- Undertakes recurring and new activities and high baseline services to provide an industrial commons for member companies
- Includes accelerated uptake of technical projects in other related IMCRC programs, with focus on specific high value projects in areas such as value chain and opportunity mapping, clustering, business model innovation and high performance workplaces.

Supporting investments

NSRIF should invest in recruitment initiatives to attract globally leading science and technology researchers to Australia to work in science, technology and innovation programmes, and provision of increased support for early career researchers, including international exchange studentships and fellowships with industry.

NSRIF should initiate a new category of 'Innovation Fellow'. The criteria for support would be world leading talented researchers and not a proposed project or programme. The fellowships would be fully funded for 10 years, reviewed after five, with appropriate money to travel and attract international visitors.

Applicant priority would be given to those with good international connections (universities and businesses). They would have to outline their records and aims in innovation in their proposal and the pathways to impact for their research. Fellowships should be awarded to an individual, not an institution, so if the institutional arrangement doesn't work they can move. The selection would be made by a joint academic/business panel.

[91] The CRC Advisory Committee is looking to simplify the CRC application process and develop other models that are 'fit for purpose'.

NSRIF should invest in *Doctoral Training Centres* that integrate both discipline-specific and generic components, modelled on successful programs in the UK and Germany. The ATN universities have already taken an initiative in this area. Information is provided in Box 12.

Box 12: ATN Industry Doctoral Training Centre (IDTC)

Industry Doctoral Training Centre (IDTC)

The IDTC, run across five universities, combines a traditional PhD thesis with specific training in professional and broad technical skills required by industry. Graduates are skilled to seamlessly work in either industry or academia throughout their careers, with the skill set for both. This should be the norm.

Significant barriers exist before programs such as the IDTC can be delivered at scale across the sector. Delivering the industry readiness and broader skills that make the IDTC such a valuable program requires additional time and resources. To really tackle research training in a meaningful way, dedicated funding will be required to underpin the extra training that is not part of a traditional PhD. But we can point to global competitor nations that have gone down this path and reaped benefit. It is a de-risked investment.

Businesses also need to be encouraged to build a culture of collaboration. This could be achieved through changes to the tax system, motivating businesses to spend the extra dollars to directly support students on industry research-focused PhDs and to hire PhD graduates who can make a real and immediate impact.

NSRIF should consider re-introduction of the *Commercialisation Training Scheme* that operated between 2007 and 2011, but with changes recommended in the evaluation undertaken in 2011. In addition, there is strong support for a *national internship plan* designed around a work-integrated learning model developed by Universities Australia in collaboration with industry organisations.

The role of the CSIRO

As mentioned on page 22, CSIRO is being positioned as Australia's *Innovation Catalyst* and to ensure that Australia's science, technology and innovation helps Australia meet the challenges and opportunities driven by the 'megatrends' shaping Australia's future[92].

Box 15: CSIRO - Innovation Catalyst

'As the nation's mission-directed research agency, we must help Australia understand and respond to accelerating global change, and the increasing integration and interdependence of human and environmental systems.

'We must help respond to digital disruption of every value chain and build Australia's digital capabilities.

'We will learn to generate, organise and analyse massive data, and deliver valuable, trusted insight across human and biophysical systems, from planetary to atomic scales. We must respond to a faster, more networked world, where innovation requires collaboration, agility and an ability to partner seamlessly across disciplines and organisational boundaries, which are themselves, being disrupted and blurred. We must help reinvent existing industries and strive to create a new industry for a changing Australian economy.'

In this way CSIRO and other government research organisations will be expected to work with research funding agencies and universities in the development of strategic and industry driven research strategies.

Governance and funding

NSRIF should operate at arm's length from Government and be constituted under legislation as a non-corporate Commonwealth entity, subject to the provisions of the Public Governance, Performance and Accountability Act 2013 within the portfolio of the Minister for Industry, Innovation and Science.

NSRIF should be governed by a Board with academic and industry interests. The Chair or CEO of the CSIRO should be a member of the Board to ensure that connections were built and maintained between the organisation and the research community, which has an opportunity for input into the design of the portfolio.

An expert committee consisting of academic and industry members should continue to advise each Council. An Advisory Board should be established for the National Research Facilities and Infrastructure Fund, and a dedicated agency should be established to manage the human capital aspects and systems, overheads and corporate support. One of the key roles for NSRIF would be to support the industry leadership expected to come from the IGCs and in a way that connects public research and business. It would be connected to the Industry Department. Its remit would be to build strong connections to industry, and particularly the IGCs.

[92] http://www.csiro.au/~/media/About/Files/Strategy/CSIRO_Strategy_2020-PDF.pdf?la=en

Responsibility for the administration of Research Block Grants should be transferred from Department of Education to NSRIF and administered in a way that supported the strategic priorities and investment strategies of NSRIF. NSRIF should have responsibility for investing in national science and research infrastructure, on advice from the NCRIS committee

NSRIF should also continue with the ERA process, but would, with the National Bureau for Innovation Research (see SSA1 above), develop a robust and credible system of research impact metrics in collaboration with the National Innovation Council.

NSRIF should be resourced at a level at least equivalent to the commitment that is reflected in Table 10 with a view to substantially increasing (at least doubling in real terms) the funds available over the next ten years.

The allocation of funding between NSRIF programme areas should be a matter for determination of the Board, in accordance with priorities established through consultation with the science community and guidance from the National Innovation Council (See SAA1). Once the initial decision is taken to establish NSRIF, implementation should follow a staged approach that ensures that research commitment is not compromised and resources are not wasted in set up costs.

Strategic Action Area 4: Support innovation and entrepreneurship in high growth local innovation ecosystems

A 2014 Report by Start-up Australia suggests that Australia has an unprecedented opportunity to transition from an economy based on resources, primary industries and domestically focused businesses to one based on high-growth knowledge-intensive businesses that can compete globally. It suggests that Australia is making good progress, but more can be done[93].

Box 16: Crossroads 2015: An action plan to develop a vibrant tech start-up ecosystem

The recent Start-up Economy study undertaken by PwC and commissioned by Google Australia projected that high-growth technology companies could contribute 4 per cent of GDP (or $109 billion) and add 540,000 jobs to the Australian economy by 2033 from a base of approximately 0.2 per cent of GDP today – but only if action is taken to address several areas of market failure relating to culture, skills, markets, funding and regulation.

Over the last two decades many countries have recognised that high-growth, technology-based businesses are important drivers of economic growth, and a growing number of governments have responded by launching programs to systematically invest in the creation and support of high-growth companies. Australia has not kept pace, and has under-invested in catalysing and supporting its high-tech industries as evidenced by the fact that we now have one of the lowest rates of start-up formation in the world, and one of the lowest rates of venture capital investment.

According to a recent World Economic Forum report, Australia's start-up ecosystem is lagging behind those of many other developed nations due to a lack of emphasis on entrepreneurship education, limited engagement with universities and poor cultural support for entrepreneurs.

http://startupaus.org/wp-content/uploads/2015/04/Crossroads-2015.pdf

Regional and local innovation ecosystems are becoming increasingly important as a foundation for industry development and transformation. They emerge around large technology intensive businesses, technology entrepreneurs, universities and venture capital investors, as a combination of vibrant creative communities with both soft and hard infrastructure. Increasingly, universities are getting behind the development of these ecosystems.

It is recommended that:

> **A *Local Innovation Initiatives Investment Fund* be established to build and sustain capability in entrepreneurship, collaboration, and start-up company formation in high growth innovation districts and emerging local entrepreneurial ecosystems. Funding should be available for collaborations between universities, other research organisations, VET providers, RDA Committees and business groupings.**

Mission and purpose

The Fund would strengthen local innovation ecosystems through investment in local initiatives where a strong business case has been made. This would include:

- Attracting talent, including fast tracking visa applications
- Skills development and training that is appropriate to the industry profile of the ecosystem
- Promoting access to InnovateAUS support, including embedding staff with the ecosystem
- Network development, 'soft infrastructure' and maintenance
- Collaborative projects, including the Global Opportunities Programme, referred to in Action 2
- New venture business development and enterprise training initiatives
- Encouraging the location of global, R&D intensive corporations, as a foreign direct investment (FDI) initiative, in collaboration with investment attraction agencies.
- Provision of hard infrastructure support, including broadband, purpose designed buildings, rental housing, community facilities, and particularly, public transport.

Funding should be based on the development of common strategic goals and the articulation of development projects in a particular area of technology. Above all funding, should encourage the further development of initiatives underway and support and capture diversity in the innovation system. It should reward innovation and entrepreneurial initiative. The Fund would identify funding categories, but invite submissions on a business and value capture basis – rather than a rules driven 'categorical' framework.

[93] StartupAUS, (2014)

Areas of potential investment interest

The following areas for potential investment by the Local Innovation Initiatives Investment Fund are identified for consideration.

Student entrepreneurship and education

Several Australian universities have been investing in a range of initiatives that support local innovation, including:

- Student oriented innovation contests and competitions, including InnovationACT, the UTS 3P Business Plan Competition, and the RMIT Business Plan Competition
- Incubators and accelerators, including ATP Innovations, University of Melbourne Accelerator Programme, UTS Hatchery, iAccelerate (Wollongong), Slingshot (Newcastle), Venture Space (UNSW), RMIT New Enterprise Fund, iLab (UQ), Flinders New Ventures Initiative, Incubate (University of Sydney) and Curtin Accelerate.

These initiatives are directed towards producing technically capable and entrepreneurially enthusiastic young people with a desire to start a business and make a serious commitment. Competitive pressures between universities in attracting talented students wanting a broader learning experience will, desirably, push this along. However, available funding is tight and often squeezed from faculty budgets.

Box 17: Melbourne Accelerator Programme (MAP)

MAP, a start-up accelerator, was established in June 2012, when a group of staff in the Melbourne School of Engineering, decided that those with ideas – and courageous enough to claim them – needed a home.

MAP's goal is to support entrepreneurs of all stages and accelerate the growth of world-class start-ups. Its vision is to raise the culture of entrepreneurship on campus. Since its inception in 2012, it has evolved into a programme that hosts a range of public events, workshops and feeder programmes to help up-skill and connect entrepreneurs of all stages.

Top start-ups are awarded Entrepreneurial Fellowships and gain access to the MAP Start-up Accelerator where they receive $20,000 funding, office space, mentoring and travel to Sydney and Silicon Valley. MAP alumni have raised over $10.0m in funding, generated almost 80 jobs and $3.5m in revenue since June 2012.

Once a year, the MAP Start-up Accelerator funds a group of start-ups (currently 8 per intake) and works intensively with them to grow their businesses. Start-ups are provided with:

- $20,000 funding
- Office space
- Networking opportunities
- Structured mentoring
- Imprimatur from the University of Melbourne
- Access to MAP networks in Sydney and Silicon Valley.

In order to be eligible for the MAP Start-up Accelerator, at least one founder needs to be a student, staff or alumni (within the last five years) from participating faculties. To date, MAP has supported 24 start-ups in total. Together these start-ups have raised over $10m in funding and forged connections to some of the best entrepreneurial minds and talent across the globe. In June 2014 MAP was ranked number 13 globally from over 300 university business incubators surveyed from 67 countries by the UBI Index.

http://themap.co/

Incubators and accelerators are supported by technology businesses and philanthropy. But for the initiatives to flourish, more 'seed' funding is required. Support could be provided by the Commonwealth through a *Student Venture Fund* that could be accessed by universities on a matching basis. It could be managed through InnovateAUS (See SAA2).

In addition, there is an urgent need to initiate additional formal *education and training programmes* in entrepreneurship and business skills, as argued in a recent report for the Chief Scientist. It is important, however, to build on what is being achieved, rather than 're-invent the wheel' with new schemes and initiatives, in a way that has characterised Australian innovation policy over the last 15 years (See page 14 above). These programmes should also recognise the important role of the VET sector in delivering management and technical skills training to SMEs

A number of Australian universities offer masters programmes in entrepreneurship, just as similar initiatives are taking place overseas. For example, UTS has recently launched a new MBA in

Entrepreneurship[94], building on expertise and experience in Sydney's 'digital creative hub'. The University of Queensland has been running postgraduate courses on innovation, entrepreneurship and commercialisation for many years. These include a course run in partnership with UniQuest developing strategies for its start-ups, which has won national teaching awards.

There is also a suite of highly regarded executive education courses across the university sector, as well as the CSIRO lean start up program and core MBA courses on innovation, leadership, and finance. Many of these programmes attract significant international participation. They are also of interest to large corporates who require a more entrepreneurial mindset among their senior executives, on the basis that it is better to 'disrupt from within' than be disrupted from without.

New ventures and innovation precincts

Several universities have established proof of concept and seed funds in collaboration with established venture investors or on their own initiative. Funds include Uniseed, QUT Bluebox, UniSA Venture Catalyst, and ANU Connect ventures. Artesian Ventures has collaborations with University of Wollongong (iAccelerate), UQ (iLab), and University of Newcastle (Slingshot).

There is also growing interest in crowd-funding, as a way of spreading risk widely, and there are there are incentives associated with the capital gains tax regime[95]. Ministers have indicated interest in easing restrictions on crowd-funding and exemption of capital gains tax on growth of start-up ventures. This report strongly supports these suggestions. There is also interest in other tax measures, such as the 'patent box', but these are not within the scope of this Report. Early stage venture investors, including angel investors, like to invest 'close to home'. Emerging innovation precincts and ecosystems are attracting venture investors where they see opportunities connected with students and staff in universities, VET providers, and research organisations.

Melbourne, UTS, Deakin, Wollongong, Newcastle, QUT, Flinders and the University of South Australia have made significant investments in developing innovation precincts. The Commonwealth has provided project funding for a number of facilities in innovation precincts. State Governments have also provided incentives through making land available, funding, and amendments to land use regulations to allow for diversified development. Changes in planning guidelines enabled Melbourne University to develop its *Carlton Connect* sustainability and innovation hub on the former Royal Women's Hospital site to provide exhibition, function and office space, as well as educational and research and development facilities.

An important regional example is the Geelong Technology Precinct, which was established to apply knowledge and advanced technology to reposition Victorian industry from traditional routinised mass production to more flexible and specialised activities. The Precinct focuses on Deakin's core research capabilities in materials, biotechnology, chemistry and environmental engineering, along with regional strengths in manufacturing and agri-processing[96].

[94] See http://www.uts.edu.au/future-students/business/business-study-areas/mba-and-executive-mba-programs/mba-entrepreneurship

[95] Fund managers seeking to raise a new venture capital fund of at least $10 million and not more than $100 million for investing in Australian businesses may be able to register the fund as an Early Stage Venture Capital Limited Partnership ESVCLP. Registration entitles a fund to flow-through tax treatment and its investors (whether resident or non-resident) receive a complete tax exemption on their share of the fund's income (both revenue and capital).
See http://www.business.gov.au/grants-and-assistance/venture-capital/esvclp/Pages/default.aspx

[96] These plans follow overseas initiatives, such as the Lüneburg Innovation Incubator where Leuphana University and the German federal state of Lower Saxony strengthened the research and economic potential of the former governmental Lüneburg district. See OECD, (2015d)

Box 14: Geelong Technology Precinct at Deakin University

The Precinct offers opportunities for collaborative and contract research, provides tenancy for technology-oriented businesses, and enables 'proof of concept' and 'industrial prototyping'. It aspires to be the leading Australian regional hub for higher degree training in science and engineering.

The precinct is the base for:

- The Australian Future Fibre Research and Innovation Centre, a partnership between Deakin University, CSIRO, VCAMM and the State and Federal Government. The Centre received a $37m Education Investment Fund grant
- The Institute for Frontier Materials (IFM), which undertakes a unique style of research combined with industry co-operation.
- A state of the Art Electron Microscopy Suite
- The Centre for Intelligent Systems Research
- CSIRO Materials and Science Engineering
- Carbon Nexus, world's first, dedicated, pilot scale Carbon Fibre Plant
- A Proof of Concept facility comprising 2,000 m2 of open floor space and 1,000 m2 of laboratory space for Metal, Intelligent Systems and Corrosion laboratories
- Metabolic Research Unit, a purpose-built molecular facility that supports research focussed on the causes and characterisation of complex metabolic diseases.
- A number of industry partners including Carbon Revolution, Kemin Nutrisurance, Victorian Centre for Advanced Material Manufacturing and the International Fibre Centre

http://www.deakin.edu.au/gtp/

There are also science and technology hubs and precincts being developed in other locations across the country, including:

- Ballarat Technology Park
- La Trobe Technology Park
- RMIT Advanced Manufacturing Precinct
- Swinburne Advanced Manufacturing and Design Centre (AMDC)
- Australian Institute for Bioengineering and Nanotechnology
- Flinders at Tonsley (South Australia)
- Future Industries Institute (South Australia)

NSW is promoting 'knowledge hubs' as industry led collaborative partnerships centred on NSW industry sectors. They bring together businesses, research organisations and industry associations. Their purpose is to share information, direct research and collaborate through shared projects to drive innovation and create shared value.

Box 18: Piivot – Sydney's Digital Creative Hub

Piivot is a UTS-initiated partnership of tech start-ups, digital, creative, cultural, corporate, government, and education organisations centred on digital creative innovation. It is directed towards entrepreneurs, partners, investors and students looking to connect, learn and work together. It is located 'right in the heart of the digital creative ecosystem' in Ultimo, Sydney, with its vibrant urban culture, world-class architecture, small bars, independent retailers and galleries.

Programmes and initiatives include:

- *Hatchery* 'pre-incubator' programme, designed to create entrepreneurs. The Hatchery is a safe and secure environment to 'hatch' students' entrepreneurial talent, with further connections to commercial accelerators, incubators and co-working spaces such as Fishburners
- *Hatchery+* programme (in development) to provide tools, techniques and support for new venture creation by students, academics and external partners, in conjunction with UTS programmes such as the new MBA in Entrepreneurship
- *Springboard Enterprises Australia*, a highly vetted expert network of innovators, investors and influencers who are dedicated to building high-growth, technology-intensive companies led by women
- *City of Sydney* start-up pilot projects to support entrepreneurs in creative and technology start-ups (in development)
- *Pollenizer* 60 day Start-up Programme. Australia's first start-up incubator has a 60-day start-up programme to help start-ups scale and grow.

http://www.piivot.sydney/

Several Australian regional and metropolitan universities have leveraged Commonwealth funding through the Education Investment Fund (EIF) to establish science and technology hubs and precincts around specific areas of technology. The EIF was an important vehicle for building these districts and ecosystems, and it should be revived.

In many parts of the world, investment in local innovation ecosystems has been associated with urban redevelopment, renewal and employment stimulation. The Prime Minister has recognised that cities are where the bulk of Australia's our economic growth can be found. Liveable cities, efficient

productive cities, the environment of cities, are regarded as major economic assets. With Commonwealth interest in the development of cities, there is an opportunity to provide further support to accelerate the development of innovation districts and local innovation ecosystems as hubs for business, industry and employment growth.

As indicated in SAA 2, a number of RDA regions have developed or are in the process of developing Regional Smart Specialisation Strategies (RS3). Other regions should be encouraged to go down this track. Smart strategies are oriented towards 'clustering' around key enabling technologies – for example, digital technologies and digital content, biotechnology, nanotechnology, micro/nanoelectronics, robotics, artificial intelligence, and advanced materials in industries that have been identified as offering potential for growth.

Strategies designed to support high growth innovation ecosystems should be linked with initiatives being developed in the Cities and Built Environment portfolio.

Governance and funding

InnovateAUS should have operational responsibility for coordinating the Local Innovation Initiatives Investment Fund. The Minister for Cities could address urban development and renewal aspects. Being local in nature, policy and funding Initiatives should be developed jointly with State/Territory Governments, universities, and build on achievements that are being made. Policy initiatives should not override the organic nature of innovation ecosystem development[97].

Funding responsibility should be determined within the context of the overall level of funding available for Science, Research and Innovation, and might include new models for public-private partnerships.

[97] Policy has not been able to replicate a Silicon Valley and very few of the many biotech clusters have achieved intended results in terms of job and wealth creation.

Strategic Action Area 5: Invest in future skills through an integrated national tertiary education system

The Australian tertiary education and training infrastructure is not adequately preparing Australia's future workforce and managers and that there is a discontinuity in responsibilities for education outcomes between the Commonwealth and States/Territories.

A high quality and well-functioning tertiary education system is not only important for students – it is a source of competitive advantage. Industry and businesses are attracted to regions and locations with a 'talent pool' of highly educated and skilled people. Access to talent is one of the primary determining factors for location decisions by knowledge intensive businesses.

It is recommended that:

> **Government take action to achieve an integrated *National Tertiary Education System* that brings together the higher education and vocational education and training systems in a way that better prepares people for Australia's future workforce needs, and ensures that resources available are allocated efficiently and effectively. The system should aim to achieve a greater integration of academic and occupational learning through a better combination of institutional and workplace learning**

Empowering people to acquire new skills and capabilities is also critical for more effective engagement in the innovation system and to avoid economic and social exclusion. This is a role for both the higher education (university) sector and the vocational education and training (VET) sector.

Priority areas for system design

The *Australian Innovation System Report*[98] indicates demand for skills in marketing, business management, financial, IT professional and IT support technicians. Higher education and VET completions are not meeting demand for these skills by innovators and exporters, and this may represent a significant future limitation to Australia's international competitiveness if skilled migration cannot make up the shortfall.

Some IT skills are currently on the Skilled Occupation List. For domestic innovators, a below-average growth rate in education and training completions in transport, plant and machinery operation may also be a limitation on more technological innovation. Modelling of future workforce needs shows that Australia faces a potential shortfall of 2.8 million in supply of skilled workers with at least diploma-level qualifications by 2025.

Submissions to the inquiry suggested that there was a shortage of people with skills acquired at university, but more significantly, technical skills acquired through the VET system. There are also skills shortages in the area of management capacity and capability, and digital literacy and design thinking. These matters are addressed below.

Professional skills

There have been several reports that have advocated greater priority for investing in teaching higher education STEM disciplines, particularly in areas relevant to Australia's growth priorities[99]. Attention has also been given to ensuring that the schools system is adequately preparing students for entry into university education, particularly through learning in mathematics, the physical sciences (including earth sciences, physics, chemistry and the material sciences), the information sciences, and engineering. There is also now growing commitment in Australia and elsewhere to programmes like Athena-SWAN to promote the careers of women in STEM research and teaching[100].

[98] Department of Industry, (2014)
[99] Kinner, (2015; Office of the Chief Scientist (Professor Ian Chubb), (2014; Prinsley & Baranyai, (2015))
[100] Science in Australia Gender Equity (SAGE) Pilot https://www.science.org.au/SAGE/Pilot

Technical skills

In 2014 the Department of Industry and Science asked the National Centre for Vocational Education Research (NCVER) to investigate the readiness of the education and training sector to meet demand from the five Industry Growth Centres where potential market opportunities have been identified[101]

The report concluded that the gap between the knowledge generated in the education system and the skills demanded by employers and individuals is widening and that there is a need for a significant cultural shift in thinking about the way skills are generated and deployed. The report also observes that the constraints on the readiness of enterprises to meet demand stem both from within the education system and the changing nature of global value chains.

The report suggests that overcoming these limitations will require:

- Better outcomes from both school and post-school education in developing generic and foundation skills. There is also a need for Asia literacy
- A priority focus on STEM, including the development of workplace skills, undergraduate or research degrees, and opportunities for continuing professional development in STEM disciplines
- Businesses to better understand their skill needs during different phases of their involvement in global value chains and to encourage workplace learning opportunities for education and training that support continuing professional development.

Box 16: NCVER research on the demand for skills in Industry Growth Centres

Employers must encourage and support a more nimble workforce, that is, one willing to learn new skills and adapt to change. This will require partnerships with schools, vocational education and training (VET) institutions, universities and research organisations. Knowledge hubs or clusters create opportunities to foster the creation of skill-intensive jobs, which can lead to innovation and productivity. These demand resources and continuous learning.
The diversity within each of the five industries, in terms of the stages of their business development and their economic activity, creates challenges in gathering statistical data. Specific issues emerged for each industry:

- In agriculture and manufacturing, older, lower-skilled workers require retraining to find acceptable jobs in their changing industries or elsewhere.
- In oil, gas and mining, recruiting and maintaining workers in remote and hazardous locations are ongoing challenges.
- In biotechnology, universities and companies must work closely to understand the business environment to thereby ensure a supply of appropriately skilled graduates.

The observations also point to the role of local innovation ecosystems in fostering the development of skill intensive jobs to meet specific system requirements. This Report has made recommendations regarding local innovation ecosystems in Action 4 above.

Management and governance skills

The Report's observations and concerns about management capacity and capability have been canvassed in Part I under the heading *The skills for innovation* (page 8). It is clear that in the contemporary business environment, it is not enough to be a great scientist, engineer, designer, marketer or financial analyst – although one or more of these skills may dominate from time to time. A well-rounded, competent and balanced management capability is fundamental.

According to the *Management Matters in Australia* study, Australian managers fall most behind world best practice in structuring their relationship to their workforces, and in particular in 'instilling a talent mindset' [102]. This is a critical area for management development as it is a proxy for innovation capability at the enterprise level. In addition, managers require entrepreneurship skills not so much to create new ventures but to renew and reposition their current organisations from within. This has become known as 'intrapreneurship'.

In the current innovation environment that gives priority to formation of new businesses, it is also essential that company boards are constituted by people who can add value to a business as well as ensure regulatory and compliance requirements are met. New board members often require education in their corporate roles and responsibilities. The Australian Institute of Company Directors performs an important service in this area.

[101] Beddie, Creaser, Hargreaves, & Ong, (2014)
[102] Green, Agarwal & others, (2009)

In addition to compliance issues, the focus of governance education should be on the role of a board in driving innovation, and managing risk not avoiding it. It should also address governance transition as businesses undergo transformation and diversification enabled by digital technologies and international engagement. Boards of new and fast growing companies require members who can create value in addressing innovation, technology and collaboration challenges. In this context, it is essential to promote gender and cultural diversity in appointments to boards/advisory councils, especially in technology-enabled innovation businesses.

Assistance and support should be provided for innovative management education in tertiary institutions that use a combination of theory based and experiential learning opportunities to ensure that current and future managers can operate in a contemporary, dynamic and complex business environment.

Skills in design thinking and digital literacy

An important element in building capability is in the area of design thinking – an observation-based methodology to solve complex problems and find solutions through logic, imagination, intuition and systemic reasoning, and to explore possibilities and create outcomes that benefit the end user. Design thinkers argue that we rely far too much on 'analytical thinking', which merely refines current knowledge and produces only incremental improvements to what currently exists.[103]

Box 20: Developing a design mindset

UTS Design Innovation Research Centre

The UTS Design Innovation Research Centre works with innovators who are seeking a different way to approach the problems they are facing. Remaining relevant in a rapidly changing world requires organisations to rethink what and how they innovate. To assist firms make this transition, the DIRC draws on design practices to develop new methods, tools, structures and most importantly leadership capabilities, for organisations to remain competitive and relevant.

We know through leadership research that Australia's management mindset will prevent us from radically exploring new opportunities and directions. A new industry engagement model is being developed for this mindset to allow organisations to embrace the level of uncertainty and complexity of the problems they will face. DIRC has started to explore what this may mean as part of the Food and Agriculture Business Industry Growth Centre, an initiative of the Australian Government.

As part of the development of a 10-year strategic plan DIRC is using a design-led process to help industry leaders better understand future customer challenges and to frame these as tangible business opportunities. This will allow new research collaborations and technology investments to start today, using an experimental model.

The success of this model will be measured by how it can shift a sector's focus from solving today's problems with an old mindset to building the industry capability to envisage transformative opportunities and leverage this into tangible collaborations and innovation activities for tomorrow.

http://www.uts.edu.au/research-and-teaching/our-research/design-innovation-research-centre

A further crucial element of capability is digital literacy. It is generally agreed that a vital part of Australia's future innovation fabric will be in industries that can successfully adopt and apply technology. Managers, workers and entrepreneurs will increasingly require an ability to leverage the digital technology that underpins the modern economy.

Digital literacy relates primarily to the knowledge and skills applied in a broad range of digital devices such as smart phones, tablets, laptops, desktop computers, production machinery and equipment, and even motor vehicles. There is a growing requirement for people with software knowledge skills who can program, instruct, and repair machines and their operating systems.

Most of the important enabling technologies being developed in research organisations and business require knowledge and skills in digital technology and the capacity to develop and/or apply software, program machinery and devices, and interrogate very large administrative and processor generated databases. As indicated earlier in the Report, digital literacy is also an important aspect of social inclusion in securing and spreading the benefits of growth.

Education and training institutions, from primary, secondary and through to tertiary *and* community education should be supported in their efforts to increase levels of digital literacy.

Work integrated learning and lifelong learning

There is a growing trend for training to move from the workplace to education and training institutions, reflecting not only cost factors, but also the demand from industry for a strong link

[103] Martin, (2009)

between occupational and academic learning, the introduction of national competency standards across a range of skill categories and occupations, and the increasing knowledge base of competency based training programs.

Universities Australia and peak industry organisations have developed a *National Strategy on Work Integrated Leaning in University Education*[104]. The proposed actions are set out in Box 21. It is vital that business and education providers commit to work integrated learning not only in universities but also in VET institutions.

Box 21: National WIL Strategy

The National WIL Strategy Proposed Actions

1. Provide national leadership to expand Work Integrated Learning (WIL)
2. Clarify government policy and regulatory settings to enable and support growth in WIL
3. Build support - among students, universities, employers across all sectors and governments - to increase participation in WIL
4. Ensure the investment in WIL is well targeted and enables sustainable, high quality experiences, stakeholder participation and growth
5. Develop university resources, processes and systems to grow WIL and engage business and community partners
6. Build capacity for more employers to participate in WIL
7. Address equity and access issues to enable students to participate in WIL
8. Increase WIL opportunities for international students and for domestic students to study offshore.

http://cdn1.acen.edu.au/wp-content/uploads/2015/03/National-WIL-Strategy-in-university-education-032015.pdf

It is no longer the case that young people learn all they need to know at school, college or university to prepare them for a long career with a single employer. The new generation of 'knowledge workers' changes employers frequently, and many start their own businesses. This creates a demand for constant skills updating, exposure to new ideas, and rejuvenation of knowledge. Some of this is available on line, but people also value non-virtual connections.

Tertiary education institutions have a key role in providing public 'spaces' for people interested in all forms of learning to access networks and identify opportunities in a range of learning formats. In particular, they support continuing professional career development, often in collaboration with industry and professional bodies. Innovation can be disruptive and people require the development of new capabilities and updating of skills as business requirements change.

In this context, learning is increasingly a continuous and lifelong commitment. While many people take their own initiative in upgrading skills, it is desirable that employers support this area of investment. Continuous learning and engagement with tertiary education also facilitates networking and mobility in the innovation system.

A balanced approach to skills development is required – an approach that integrates the academically based and occupationally based technical and non-technical skills, together with superior management capabilities as a means to unlock future innovation potential and productivity growth.

Education systems integration

As indicated in this part of the Report, there is a growing interaction between professional and technical learning, between theory-based, experiential, and competency based learning, and the blurring of the boundaries between them. Businesses have a requirement for both university-educated professionals and VET trained technicians. It is no longer helpful to see stark contrasts between higher education and VET in the level and types of learning and qualifications they deliver.

Universities and VET providers are addressing this through pathway programmes and articulation arrangements that allow students to progress from a certificate qualification through to an advanced diploma, and then bachelor's degree, and subsequent higher level qualifications as career opportunities and education needs arise[105]. But there is little national consistency and arrangements are negotiated on an institution-to-institution basis.

Student demand driven approaches and the less than transparent activities of many for-profit VET providers, as well as the complex regulatory framework, are not helpful in ensuring that skills required

[104] Universities Australia et al., (2014)

[105] There are also 'reverse' pathway programs as university graduates look to the VET sector to acquire the technical skills and knowledge necessary in a workplace context.

for Australia's innovation future are being delivered. It is important to address skills development in an integrated, national approach. Discussion and debate within the education sector indicates that:

- The current configuration of institutional roles and responsibilities in the tertiary education system is not desirable from the perspective of students, industry or the economy
- The system is also not sustainable in the face of needed policy changes and new directions in innovation and improving productivity
- There is an urgent need for an innovation 'system-wide' approach to post-secondary education delivered at the national level, with a focus on outcomes.

The expectation of the 'unified national system' (the Dawkins reforms) that joint programs and facilities would emerge between TAFE colleges and universities has not really emerged except perhaps in the Victorian 'dual sector' universities. It follows that action must be taken to achieve a much closer connection between the higher education and vocational education and training systems towards a goal of achieving an integrated national tertiary education system for Australia.

Governance

Priority should be given to the development of an integrated national tertiary education strategy and system to meet education and skill requirements. The division of Commonwealth and State responsibilities for funding, regulation and accreditation is no longer tenable. These issues are currently a matter of public debate and should be addressed as a high priority.

PART III: ATTACHMENTS

Attachment 1: Commonwealth Expenditure on Science, Research and Innovation

The 2015-16 *SRI Budget Tables*[106], released by the Department of Industry, Innovation and Science on 30 July 2015, provide summaries of Australian Government support for science, research and innovation by sector, government portfolio and socio-economic objective. They provide detailed information on Australian Government research activities, R&D granting programs and other support for science, research and innovation. In addition, the tables provide information on industry contributions to rural research. An extract from the tables is reproduced below.

Table 9: Government Expenditure of Science, Research and Innovation ($m)

Programme / Activity	Estimated Actual 2014-15	Budget Estimate 2015-16
Agriculture		
A Competitive Agriculture Sector - boosting farm profits through rural R&D	19.3	29.2
Carbon Farming Futures - Action on the Ground	9.9	4.3
Carbon Farming Futures - Extension and Oureach	6.1	3.7
Carbon Farming Futures - Filling the Research Gap	26.3	9.5
Centres of Excellence - Biosecurity Risk Analysis and Research	1.8	1.8
Dairy Australia Limited	20.9	22.3
Fisheries Resources Research Fund	0.3	0.4
Fishing Industry Research	17.4	18.1
Grains	68.2	69.1
Horticulture Research	42.5	42.5
Meat Research	54.9	54.0
Mechanical Fuel Load Reduction Trial	0.0	0.1
National Landcare Programme Innovation Grants	9.5	4.9
Other Rural Research	24.1	22.6
Plant Biosecurity and Response Reform	0.1	0.0
Rural Industries R&D Corporation	13.0	12.2
Science and Innovation Awards for Young People in Agriculture, Fisheries and Forestry	0.0	0.0
Wool Research	12.3	11.5
	326.7	306.3
Attorney-General's		
ARC linkage grant - Return, Reconcile, Renew: understanding the history, effects and opportunities of repatriation and building an evidence base for the future.	0.1	0.1
Australia Council - Synapse program	0.2	0.1
Australian Institute of Criminology - Criminology Research Grant Program	0.7	0.4
Australian Institute of Criminology - National Drug and Law Enforcement Research Program	0.7	0.3
Australian Institute of Criminology Research Program	3.0	3.0
Australian National Maritime Museum	0.2	0.2
	4.8	4.0
Communications		
ICT Centre of Excellence	21.4	21.0
Defence		
Australian Civil-Military Centre - Research and Lessons Learnt	0.8	0.7
Defence Industry Innovation Centre	3.1	3.1
Defence Science and Technology Organisation (DSTO)	416.5	431.6
Explosive Ordinance - Required materials for Proof and Equipment Unit	0.1	0.0
Joint Force Integration - IMD Study	0.2	0.7
Mental Health - LASER Resilience Research	0.1	0.2
Strategic Health - Australian Defence Human Research Ethics Committee	0.1	0.1
	420.8	436.5
Education and Training		
Australia Consensus	1.0	1.0
Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS)	3.0	0.8
Australian Postgraduate Awards	276.1	282.1
Australian Research Council (ARC)	853.1	789.7
Clean Energy Initiative (Education Investment Fund)	38.3	0.0
Collaborative Research Network Program	10.3	9.3
Funding for Higher Education Research Promotion	4.7	4.7
Giant Magellan Telescope	21.9	0.0
International Postgraduate Research Scholarship	22.2	22.4
Joint Research Engagement Program	356.1	360.2
National Collaborative Research Infrastructure Strategy	100.1	150.0
National Institutes Program - ANU Component	191.3	192.3
National Security College	0.5	0.5
Research Infrastructure Block Grants	239.4	242.2

[106] http://www.industry.gov.au/innovation/reportsandstudies/Documents/2015-16ScienceResearchAndInnovationBudgetTables.xlsx

Programme / Activity	Estimated Actual	Budget Estimate
Research Investment Adjustment Scheme	0.0	8.0
Research Training Scheme	676.7	649.8
Sustainable Research Excellence in Universities	185.4	238.7
The Australian Institute for Nanoscience	6.8	0.0
	2,986.9	2,951.8
Environment		
Antarctic Division	94.8	93.9
Australian Biological Resources Study	2.0	2.0
Bureau of Meteorology Research Activities	26.8	26.6
Bush Blitz Strategic Taxonomy Grants Scheme	0.7	0.5
Carbon Farming Futures - Methodology Development	0.5	0.1
Environmental Water Knowledge and Research	1.9	1.9
Great Barrier Reef Foundation - contribution	3.1	3.1
Great Barrier Reef Marine Park Authority	1.0	1.0
Indigenous Carbon Farming Fund	0.4	0.4
Marine and Biodiversity Research	1.0	0.0
National Climate Change Adaptation Research Facility-support	2.8	3.3
National Environmental Research Program	9.4	0.0
National Environmental Science Programme	8.6	21.5
Natural Resource Management Planning for Climate Change	1.3	1.2
Office of Water Science	19.6	19.5
Supervising Scientist	14.7	15.4
Water Resource Assessment and Research	0.2	0.2
	188.8	190.6
Foreign Affairs and Trade		
ARC Linkage Grant - Protecting the Australian Passport	0.1	0.0
Australian Centre for International Agricultural Research	101.1	100.1
	101.2	100.1
Health		
45+ Study	0.1	0.0
Australian Burden of Disease Study	2.6	0.0
Australian Longitudinal Study on Male Health	1.4	2.2
Australian Longitudinal Study on Women's Health	2.9	1.2
Australian National Preventive Health Agency Research Fund	1.3	0.9
Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) - Radiation in Health Care - Safe and Better Use	1.9	1.8
Australian Sports Commission Research Programs - Extra mural	1.6	1.6
Australian Sports Commission Research Programs - Intramural	2.5	2.6
Bettering the Evaluation and Care of Health - BEACH	0.3	0.0
Cancer Clinical Trials	7.0	7.0
Cancer data to improve cancer care	0.6	0.6
Cancer Research	4.8	4.8
Chronic Disease Prevention and Service Improvement Fund	0.3	0.0
Disease Prevention and Health Promotion in Medicare Locals Programme	0.7	0.0
Drug and Alcohol Research	9.5	7.8
Health Surveillance Fund - Research Centres	9.7	9.5
Improving lung cancer outcomes	0.2	0.5
Maintaining support for women with gynaecological cancers	1.0	0.6
Medical Research Future Fund	0.0	10.0
National Acoustic Laboratories	4.3	4.3
National Centre for Immunisation Research and Surveillance	0.8	0.9
National Health Survey	1.6	1.6
NHMRC Research Grants	930.1	845.8
Primary Health Care Research Evaluation and Development - Australian Primary Health Care Research Institute	6.8	0.0
Primary Health Care Research Evaluation and Development - Primary Health Care Research and Information Service	1.4	0.0
Three dedicated Prostate Cancer Research Centres (two centres funded from 2008-09 and a third from 2013-14)	4.6	4.7
	997.8	908.4
Industry Innovation and Science		
Australia-China Science and Research Fund	0.5	1.6
Australia-India Strategic Research Fund	6.3	4.0
Australian Astronomical Observatory	11.8	11.9
Australian Institute of Marine Science (AIMS)	38.8	40.5
Australian Nuclear Science & Technology Organisation (ANSTO)	253.9	192.6
Australian Renewable Energy Agency	267.3	196.9
Automotive Transformation Scheme	169.5	152.6
Carbon Capture and Storage (CCS) Flagships	61.1	58.0
Clean Technology Innovation Programme	7.5	1.7
Commercialisation Australia	40.9	7.0
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	745.3	749.7
Competitive Pre-Seed Fund	0.8	0.0
Cooperative Research Centres Programme	146.1	146.7
Enterprise Connect	1.7	0.6

Programme / Activity	Estimated Actual	Budget Estimate
Entrepreneurs' Programme - Commercialising Ideas	4.3	35.6
Entrepreneurs' Programme - Research Connections	0.2	2.8
Establishment of an ICT-enabled Research Laboratory - Commonwealth Assistance	6.7	2.7
Geoscience Australia	126.8	121.3
Green Car Innovation Fund	0.1	0.0
Industry Growth Centres Initiative- Commercialisation Fund	1.0	12.0
Industry Growth centres Initiative- Project Fund	0.0	7.0
Innovation Investment Fund including Innovation Investment Follow-on Fund	29.7	34.7
Low Emissions Technology Demonstration Fund	0.0	40.0
National Low Emissions Coal Initiative	31.6	16.9
National Measurement Institute	7.5	7.5
R&D Refundable Tax Offset	-50.0	-25.0
R&D Tax Incentives - Non Refundable	980.0	960.0
R&D Tax Incentives - Refundable	2,040.0	1,969.0
Square Kilometre Array Radio Telescope Project	7.6	6.9
	4,936.9	4,755.2
Infrastructure and Regional Development		
ANCAP-Vehicle Testing/Stars on Cars	1.1	1.1
Funding to Transport Certification Australia - Heavy vehicle telematics and the Intelligent Access Project	0.5	0.5
Payments to Austroads/ARRB Transport Research Ltd.	3.1	3.2
Study on the effectiveness of ABS for motorcycles	0.0	0.0
	4.7	4.8
Prime Minister and Cabinet		
Improved Indigenous population projections for policy and planning	0.0	0.0
Indigenous Populations project (CAEPR)	0.3	0.3
Strategic Indigenous Research (CAEPR)	0.4	0.4
Victorian Aboriginal Child Mortality Study	0.2	0.0
	0.9	0.7
Social Services		
Additional funding for LSIC, LSAC, HILDA, and BNLA	0.0	6.0
ARC Linkage Grant - Centre of Excellence for Children and Families over the Life Course	0.2	0.2
ARC Linkage Grant - Creating the conditions for collective impact: transforming the child serving system in disadvantaged communities.	0.4	0.0
ARC Linkage Grant - Enhancing mothers' engagement with the workforce in the preschool years	0.2	0.2
Building a New Life in Australia Longitudinal Study of Humanitarian Migrants (Australian Institute of Family Studies)	1.2	1.5
Household, Income and Labour Dynamics in Australia (HILDA) Survey	10.1	9.3
Intercountry Adoption – Australian / International based research	0.1	0.0
Longitudinal study - Journey's Home	0.1	0.0
Longitudinal Study of Indigenous Children (LSIC)	3.3	3.0
Longitudinal Survey of Australian Children (LSAC)	8.5	7.8
National Disability Research and Development Agenda	0.1	2.1
National Survey on Community Attitudes to Violence Against Women (VicHealth)	0.6	0.0
Personal Safety Survey (Australian Bureau of Statistics)	5.5	0.0
	30.1	29.9
Veterans' Affairs		
Australian Centre for Post-Traumatic Mental Health	1.3	1.3
Australian War Memorial - Official Histories	0.1	2.6
Department of Veteran's Affairs - Family Study Research	0.4	0.0
Department of Veterans' Affairs Applied Research Program	2.5	2.5
Veteran Health Research	1.3	1.3
	5.5	7.6
Total Australian Government support	**10,032.7**	**9,717.0**

Attachment 2: Government Policy Initiatives, Reviews, and Commissioned Research Reports Relating to Innovation: 2000-2015

The following is a listing of published reports and papers prepared by or for Government that have addressed innovation and aspects of collaboration between research organisations, industry and government over the last 15 years. The documents are still generally available. This list does not include unpublished consultants reports prepared for government, or the numerous unsolicited research and advocacy publications issued by industry, business, and academic associations.

Government policy statements

1. Knowledge and Innovation: A Policy Statement on Research and Research Training (Minister for Education Training and Youth Affairs 1999)
2. Backing Australia's Ability: Real Results, Real Jobs. (Prime Minister 2001)
3. Backing Australia's Ability: Building our Future through Science and Innovation (Prime Minister 2004)
4. Industry Statement. Global Integration: Changing Markets, New Opportunities (Minister for Industry Tourism and Resources 2007)
5. Transforming Australia's Higher Education System (Minister for Education Employment and Workplace Relations 2009)
6. Powering Ideas An Innovation Agenda for the 21st Century (Minister for Innovation Industry Science and Research 2009)
7. Strategic Roadmap for Australian Research Infrastructure, (Department of Innovation Industry Science and Research 2011)
8. Research Skills for an Innovative Future (Department of Innovation Industry Science and Research 2011)
9. National Research Investment Plan (Department of Industry Innovation Science Research and Tertiary Education 2012)
10. Rural Research and Development Policy Statement, (Minister for Agriculture Fisheries and Forestry 2012)
11. A Plan for Australian Jobs: The Australian Government's Industry and Innovation Statement (Department of Industry Innovation Science Research and Tertiary Education 2013)
12. Industry innovation and competitiveness agenda: An action plan for a stronger Australia (Minister for Industry and Science 2014)
13. Boosting the commercial returns from research (Australian Government 2014)
14. Science and Research Priorities (Australian Government 2015)
15. The Industry Growth Centres Initiative (Department of Industry and Science 2015)
16. Agricultural Competitiveness White Paper: Stronger Farmers Stronger Economy, (Minister for Agriculture 2015)

Policy reviews, inquiries, and reports

1. The Chance to Change (Chief Scientist (Dr Robin Batterham) 2000)
2. Investing in Knowledge for the 21st Century, (Chief Scientist (Dr Robin Batterham) 2000)
3. Evaluation of the CRC Program (Howard Partners 2003)
4. Report of the Science and Innovation Mapping Taskforce (Science and Innovation Mapping Taskforce 2003)
5. Report of the National Research Infrastructure Taskforce (National Research Infrastructure Taskforce 2004)
6. ICT Use and Productivity: A Synthesis from Studies of Australian Firms (Productivity Commission 2004)
7. The Role of Creativity in the Innovation Economy (PMSEIC 2005)
8. NCRIS Strategic Roadmap (NCRIS Advisory Committee 2006, 2008)
9. Public Support for Science and Innovation (Productivity Commission 2007)
10. Review of Australian Higher Education (Bradley et al. 2008)
11. Collaborating to a purpose: review of the CRC Program (O'Kane 2008)
12. Building Australia's Research Capacity, Report from the House of Representatives Standing Committee on Industry, Science and Innovation (Parliament 2008)

13. Venturous Australia – Building Strength in Innovation (Review of the National Innovation System (Cutler Review) 2008)
14. Empowering Change: Fostering Innovation in the Australian Public Service (Management Advisory Committee 2010)
15. Focussing Australia's Publicly Funded Research Review: Maximising the Innovation Dividend, (Department of Innovation, Industry, science and Research, 2011)
16. Rural Research and Development Corporations (Productivity Commission 2011)
17. National Strategic Rural Research and Development Investment Plan (Rural Research and Development Council 2011)
18. Report of the non-Government members of the Prime Minister's Taskforce on Manufacturing (Prime Minister's Manufacturing Taskforce 2012)
19. Strategic Review into Health and Medical Research (McKeon et al. 2013)
20. Science, Technology, Engineering and Mathematics: Australia's Future (Office of the Chief Scientist (Professor Ian Chubb) 2014)
21. Growth Through Innovation and Collaboration: A Review of the CRC Program (Miles 2015)
22. Review of research funding and policy (Watt et al. 2015 (in progress)

Insights from the learned academies

1. Research Engagement for Australia (Academy for Technological Sciences and Engineering 2015)
2. The role of science, research and technology in lifting Australian productivity:Report for the Australian Council of learned academies (Bell et al. 2014)
3. Strengthening Links Between Industry and Public Sector Research Organisations (Academy for Technological Sciences and Engineering 2011)

Research commissioned by the Department of Industry and Science and predecessor agencies

1. Enabling the Virtuous Cycle: Identifying and Removing Barriers to Entrepreneurial Activity by Health and Medical Researchers in the Higher Education Sector (Johnston, Matthews, and Dodgson 2000)
2. International Trends in Public Sector Support for Research and Experimental Development: A Preliminary Analysis (Matthews and Johnston 2000)
3. A Study of Government R&D Expenditure by Sector and Technology (Matthews and Howard 2000)
4. Mapping the Nature and Extent of Business-University Interaction in Australia: A Study for the Australian Research Council (Howard Partners 2001)
5. Commonwealth Support for Science and Innovation: Options for Developing an Analytical Perspective (Matthews 2002)
6. Emerging Issues for Cross Disciplinary Research: Conceptual and Empirical Dimensions (Grigg, Johnston, and Milstrom 2003)
7. Industry Clusters: A Review (Johnston 2003a).
8. A Study of Australian Participation in Multilateral Megascience Projects (Johnston 2003b)
9. Best Practice Processes for University Research Commercialisation (Johnston, Howard, and Grigg 2003)
10. Embracing change: case studies on how Australian firms use incremental innovation to support growth (Thorburn and Langdale 2003)
11. Patterns of Innovation in Australian Companies (Johnston 2004)
12. Assessment of the Utility to Australia of the Intelligent Manufacturing Systems Program as a tool for International, Industrial R&D Collaboration (Johnston and Howard 2004)
13. Digital Factories: the Hidden Revolution in Australian Manufacturing: A Study of the use of Information and Communications Technologies by non-ICT Manufacturing Companies (Howard Partners 2005a)
14. The Emerging Business of Knowledge Transfer: Creating Value From Intellectual Products and Services (Howard Partners 2005b)
15. Knowledge Exchange Networks in Australia's Innovation System: Overview and Strategic Analysis (Howard Partners 2005c)
16. Absorbing innovation by Australian enterprises: the role of absorptive capacity (Scott-Kemmis 2007)

17. Knowledge Transfer and Australian Universities and Publicly Funded Research Agencies: A Report to the Department of Education, Science and Training (PhillipsKPA 2006)
18. The role of intermediaries in support of innovation (Howard Partners 2007)
19. Recognising the full cost of university research: a discussion paper (Allen Consulting Group 2008)
20. Management Matters in Australia: Just How Productive Are We? (Green 2009)
21. Employer Demand for Researchers in Australia (Allen Consulting Group 2010)
22. Innovation for business success: Achieving a systematic innovation capability (Samson 2010).
23. Higher Education Base Funding Review (Lomax-Smith, Watson, and Webster 2011)
24. Examining the Full Cost of Research Training (Deloitte 2011)
25. Better use of skills, better outcomes: A research report on skills utilisation in Australia (Skills Australia 2012)
26. Design for manufacturing competitiveness (Bucolo and King 2013)
27. The Future of Management Education (Australian Business Deans Council 2014)
28. Engaging Employers in Work Integrated Learning: Current State and Future Priorities (PhllipsKPA 2014)
29. The quality of teaching in VET (Wheelahan and Moodie 2015)

Departmental documents

1. Australian Innovation System Reports (annual) (Department of Industry 2014, Department of innovation Industry Science and Research 2012a, 2011b, Department of Industry 2013)
2. Industry Policy Reports 2010-2015 (periodic) (Department of Industry and Science Various)
3. National Survey of Research Commercialisation (bi-annually) (Department of Industry and Science 2015, Department of Innovation Industry Science and Research 2012b, 2011c, Department of Education Science and Training 2006, 2004, Australian Research Council 2002)
4. Collaboration and other factors influencing innovation novelty in Australian businesses (Industry Policy Division DITR 2006)
5. Innovation and Raising Australia's Productivity Growth: submission to the House of Representatives Standing Committee on Economics Inquiry into Raising the Level of Productivity Growth in the Australian Economy (Department of Innovation Industry Science and Research 2009)
6. Australian key innovation indicators data card (Department of Industry and Science 2014)
7. Intellectual Property Scorecard (Department of Industry and Science Various years)

Attachment 3: Brief Overview of Roles and Functions of Overseas Innovation Agencies

Innovate UK

Innovate UK is the UK's innovation agency107. Its role is to fund, support and connect innovative British businesses through a unique mix of people and programmes to accelerate sustainable economic growth. Innovate UK began operations on 1 July 2007. Its role is to help companies take their ideas on the difficult journey to market by providing them with a powerful array of programmes and tools.

Funding for research, development and demonstration projects ranges from proof of concept grants and feasibility studies to large multi-partner collaborative research and development projects. During the year 2014-15 the agency opened a total of 104 new competitions for funding. Other resources include the network of Catapult centres, which are a major boost to the UK's ability to transform ideas into new products and services in specific fields.

Innovate UK also offers knowledge sharing opportunities for academia and business, facilitate networking to boost open innovation and provide the route for UK businesses to access European support for innovation and technology.

In 2011 Innovate UK launched a four year strategy designed to accelerate economic growth by stimulating and supporting business led innovation. The strategy Concept to Commercialisation was backed by a budget of more than £1bn over the period and was designed to generate investment in innovation of around £2.5bn, including contributions from business and partners. It concentrated on five strategic themes:

- Accelerating the journey between concept and commercialisation
- Connecting the innovation landscape
- Turning government action into business opportunity
- Investing in priority areas based on potential
- Continuously improving capability.

In the 2014-15 financial year, the Innovate UK budget amounted to £615.9m (2013-14: £585.6m). The budget included £130m allocated for Catapult centres, £50.2m for Smart and £30m for the Biomedical Catalyst. Innovate UK employs 324 staff.

Enterprise Ireland

Enterprise Ireland (EI) 108 is the Irish state economic development agency focused on helping Irish-owned business deliver new export sales. The aim of EI is to accelerate the development of Irish enterprises capable of achieving strong positions in global markets resulting in increased national and regional prosperity and purchasing power. EI is a body corporate established by the Industrial Development (Enterprise Ireland) Act 1998.

EI provides funding and support for companies - from entrepreneurs with business propositions for a high potential start-up through to large companies expanding their activities, improving efficiency and growing international sales. It also provides funding and supports for university based researchers to assist in the development, protection and transfer of technologies into industry via licensing or spin-out companies.

Specific programme areas are:

- Support for companies focused on growth through international sales. It provides 'export ready' services, market research, an international office network, trade missions and events, and assists in developing export sales capability.

[108] http://www.enterprise-ireland.com/en/Productivity/ and http://www.enterprise-ireland.com/EI_Corporate/en/Publications/Reports-Published-Strategies/2014-Annual-Report-and-Accounts-English.pdf

- Support for both companies and researchers in Higher Education Institutes to develop new technologies and processes that will lead to job creation and increased exports. This covers research commercialisation support, technology transfer support, spinouts, and industry collaboration projects
- Customised management development programmes, delivered in collaboration with leading international providers, to inspire business leadership, provide the tools and techniques to operate more effectively, and to achieve business results in international markets.
- Enhancing competitiveness issues through introduction to best industry practices access to a range of competitiveness building tools, including the Company Competitiveness Health Check, the Lean Offer and the Green Offer. Supports are designed to build experience, knowledge and capability of people to improve company performance and ensure a strong competitiveness position in global markets

Applied Research Enhancement (ARE) Centres are funded by EI with the purpose of providing specialised expertise, research and development capabilities and access to state of the art equipment to companies. Companies may engage with AREs under a number of EI funded opportunities including EI vouchers and Innovation Partnerships. The AREs are divided sectorally into:

- ICT and Software
- Bio-Life Sciences and Pharmaceuticals
- Bio-medical Devices and Materials

EI has industry development priorities in food, internationally trade services, software and education, life science and industry, construction and consumer markets.

In 2014 Enterprise Ireland was allocated €311m, and as of 31 December 2014 employed 631 staff (excluding short term overseas posts).

Tekes: Finnish Funding Agency for Innovation

Tekes [109] is the most important publicly funded expert organisation for financing research, development and innovation in Finland. It boosts wide-ranging innovation activities in research communities, industry and service sectors and promotes a broad-based view on innovation: besides funding technological breakthroughs, Tekes emphasises the significance of service-related, design, business, and social innovations.

Tekes works with the top innovative companies and research units in Finland. Every year, Tekes finances some 1,500 business research and development projects, and almost 600 public research projects at universities, research institutes and universities of applied sciences. Research, development and innovation funding is targeted to projects that create in the long-term the greatest benefits for the economy and society. Tekes does not derive any financial profit from its activities, nor claim any intellectual proprietary rights.

Tekes employs approximately 400 people in Finland and abroad. This is a significant commitment for a nation with a population of 5.4 million. Tekes, like all of the other agencies referred to, has an international focus.

[109] http://www.tekes.fi/en/tekes/

Attachment 4: Brief Overview of Roles and Functions of Overseas Research Funding Agencies

The UK Engineering and Physical Sciences Research Council (ESPRC)

EPSRC is the main UK government agency for funding research and training in engineering and the physical sciences, investing more than £800 million a year in a broad range of subjects - from mathematics to materials science, and from information technology to structural engineering[110].

EPSRC has a mission to:

- Promote and support, by any means, high quality basic, strategic and applied research and related postgraduate training in engineering and the physical sciences.
- Advance knowledge and technology (including the promotion and support of the exploitation of research outcomes), and provide trained scientists and engineers, which meet the needs of users and beneficiaries (including the chemical, communications, construction, electrical, electronic, energy, engineering, information technology, pharmaceutical, process and other industries), thereby contributing to the economic competitiveness of the United Kingdom and the quality of life.

EPSRC provides substantial funding to a number of large research projects and centres in the UK, including:

- Centres for doctoral training - researcher-led centres, industrial doctorate, digital economy, energy, nanoapplications, complexity science, life science interface, engineering doctorate
- EPSRC Centres for Innovative Manufacturing - Centres of research excellence working with industry in different areas of manufacturing
- Interdisciplinary research collaborations (IRCs) - Centres of internationally-acknowledged scientific and technological excellence, generally involving several universities together with industrial partners

The Council is funded through the Department for Innovation and Skills and reports to the Minister. The 2015-16 budget is £898m[111] ($A 1,905m). There are six other research funding councils: Arts and Humanities Research Council (AHRC); Biotechnology and Biological Sciences Research Council (BBSRC); Economic and Social Research Council (ESRC); Medical Research Council (MRC); Natural Environment Research Council (NERC); Science and Technology Facilities Council (STFC)

Canada Natural Sciences and Engineering Research Council (NSERC)

The Natural Sciences and Engineering Research Council of Canada (NSERC) aims to help make Canada a country of discoverers and innovators for the benefit of all Canadians112. NSERC came into existence in May 1978. University-based research had previously been supported through the National Research Council.

The Council collectively represents the academic research and private sector R&D communities in natural sciences and engineering, as well as other stakeholder groups in the Canadian innovation system. The Council's main responsibilities are to set the strategy and high-level policies for NSERC, and to review and evaluate performance.

NSERC's role is to make investments in people, discovery and innovation to increase Canada's scientific and technological capabilities for the benefit of all Canadians. NSERC invests in people by supporting postsecondary students and postdoctoral fellows in their advanced studies. It promotes discovery by funding research conducted by postsecondary professors and foster innovation by encouraging Canadian companies to participate and invest in postsecondary research and training.

NSERC provides support for every stage of research—from first discovery to final innovation. These include investments in S&T priority areas that keep Canada on the leading edge of opportunities for

[110] https://www.epsrc.ac.uk/
[111] https://www.epsrc.ac.uk/about/facts/budget/
[112] http://www.nserc-crsng.gc.ca/NSERC-CRSNG/vision-vision_eng.asp

future growth; and in strategic areas that are developed in consultation with industry, academia and the Government of Canada. Over the last 10 years, NSERC has invested more than $7 billion in basic research, projects involving partnerships between postsecondary institutions and industry, and the training of Canada's next generation of scientists and engineers.

Planned spending for 2015-16 amounts to $C1.0 billion, allocated between three programme areas: People (research talent, $C276m); Discovery (advancement of knowledge, $C392m); Innovation (Research partnerships, $C352m). The Social Sciences and Humanities Research Council (SSHRC) and the Canadian Institutes of Health Research (CIHR) support and promote high-quality research in their relevant disciplines and areas. NSERC reports to Parliament through the Minister of Industry.

The US National Science Foundation

The National Science Foundation (NSF)113 is an independent federal agency created by Congress in 1950 'to promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense…' With an annual budget of $7.3 billion (FY 2015), it is the funding source for approximately 24 per cent of all federally supported basic research conducted by America's colleges and universities. In many fields such as mathematics, computer science and the social sciences, NSF is the major source of federal backing.

It fulfils its mission chiefly by issuing limited-term grants – currently about 11,000 new awards per year, with an average duration of three years – to fund specific research proposals that have been judged the most promising by a rigorous and objective merit-review system. Most of these awards go to individuals or small groups of investigators. Others provide funding for research centres, instruments and facilities that allow scientists, engineers and students to work at the outermost frontiers of knowledge.

NSF's goals – discovery, learning, research infrastructure and stewardship – provide an integrated strategy to advance the frontiers of knowledge, cultivate a world-class, broadly inclusive science and engineering workforce and expand the scientific literacy of all citizens, build the nation's research capability through investments in advanced instrumentation and facilities, and support excellence in science and engineering research and education through a capable and responsive organization. It likes to say that NSF is 'where discoveries begin'.

In the past few decades, NSF-funded researchers have won some 214 Nobel Prizes as well as other honours too numerous to list. These pioneers have included the scientists or teams that discovered many of the fundamental particles of matter, analysed the cosmic microwaves left over from the earliest epoch of the universe, developed carbon-14 dating of ancient artefacts, decoded the genetics of viruses, and created an entirely new state of matter called a Bose-Einstein condensate.

NSF also funds equipment that is needed by scientists and engineers but is often too expensive for any one group or researcher to afford. Examples of such major research equipment include giant optical and radio telescopes, Antarctic research sites, high-end computer facilities and ultra-high-speed connections, ships for ocean research, sensitive detectors of very subtle physical phenomena and gravitational wave observatories.

Another essential element in NSF's mission is support for science and engineering education, from pre-K through graduate school and beyond. Funded research is thoroughly integrated with education to help ensure that there will always be plenty of skilled people available to work in new and emerging scientific, engineering and technological fields, and plenty of capable teachers to educate the next generation.

Science Foundation Ireland

Science Foundation Ireland (SFI) is the national foundation for investment in scientific and engineering research114. SFI invests in academic researchers and research teams who are most likely

[113] http://www.nsf.gov/about/glance.jsp

[114] http://www.sfi.ie/about/

to generate new knowledge, leading edge technologies and competitive enterprises in the fields of science, technology, engineering and maths (STEM).

The Foundation also promotes and supports the study of, education in, and engagement with STEM and promotes an awareness and understanding of the value of STEM to society and, in particular, to the growth of the economy. It also advances co-operative efforts among education, government, and industry that support its fields of emphasis and promotes Ireland's ensuing achievements around the world.

SFI has a budget of €154m ($A241m) in 2015. It also receives significant support from the EU science budget, Horizon 2020. This is a significant budget provision for a country with a population of 4.6 million. It reflects a commitment to invest in research to drive industry and economic development.

Singapore Science and Engineering Research Council (SERC)

A*STAR's[115] Science and Engineering Research Council (SERC) promotes public sector research and development in the physical sciences & engineering. SERC:

- Supports world-class research in A*STAR institutes in a wide range of fields including communications, data storage, materials, chemicals, computational sciences, microelectronics, advanced manufacturing and metrology
- Plans and actively promotes research in strategic areas to encourage greater multidisciplinary research and collaborations across industries, institutes and sectors to create the knowledge and intellectual property that will drive the development of knowledge-intensive industries
- Cultivates and engages an extensive network of industry partners via various funding schemes and attachment programmes to facilitate a seamless flow of technologies from conception to commercialisation
- Identifies and nurtures talented scientists and engineers to provide a ready pipeline of talent to academic institutions and partners.

SERC manages seven research institutes and several state-of-the art centres and facilities with core competencies in the above-mentioned fields to tackle global technological challenges and create future industries from its headquarters at Fusionopolis, Singapore's iconic hub for science and technology research.

For the period 2011-2015 SERC will receive $16.1 billion ($3.2 billion annually). Singapore has a population of 5.4 million. This compares with the US National Science Foundation which invests $US 7.3 billion ($A10 billion).

[115] A*STAR is The Agency for Science, Technology and Research. It is Singapore's lead public sector agency that "spearheads economic oriented research to advance scientific discovery and develop innovative technology". See http://www.a-star.edu.sg/About-A-STAR/Science-and-Engineering-Research-Council.aspx

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