Challenges for Australian Research & Innovation

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Executive Summary

Australia is experiencing a public health crisis and a challenge of economic recovery. The crisis and the challenge sit in front of a more fundamental threat to Australia's future that lies in the need to respond to the forces of climate change and move from an economy where wealth has been created by exploitation of mineral fuels and consumer demand driven by high levels of immigration, to one driven by knowledge and technology. We must move from a second world to a first-world nation.

Australia must look for new sources of growth in this post-carbon future. These sources of growth will be built on the development and application of new technologies to revitalize industries that suffered as a result of the importation of cheaper manufactured goods, and the creation of "new industries" formed around the application of new technologies, such as big data and analytics, automation and robotics, simulation, visualization and augmented reality, and cloud based platforms.

New sources of growth will be the outcome of a national commitment to research, development, and innovation within a framework of a *National Recovery Plan* that will form the basis of a National Industrial Strategy.

Nations have done well when they start planning for the future in the midst of a crisis. Without reverting to protectionism, Australia must become more self-sufficient in the production of goods and services that have relied on complex supply chains, which can be dislocated in the event of a crisis. Risks must be managed. Many would argue that we have lost the capacity to make things – although we are good at consuming them.

The crisis has pointed to the strength of Australian agriculture, but even there we export much of the raw produce and let others do the processing - and then we bring it back again as a manufactured product. We allowed the wool industry to largely disappear as a result of agri-politics. And we allowed manufacturing to disappear by a failure to respond to the challenge of international competition – continuing to produce fair average quality commodity-based products, whilst others charged ahead based on a heavy commitment to RDI.

We must dispense with the idea that an active industrial strategy is about "picking winners", that we can import RDI from overseas, and address system failures such as the very poor interaction between industry and universities. We can take the lead from the *Australia 2030* Innovation Strategy and look for *national missions* that will guide RDI investment and the creation of new industries.

Australian investment in RDI has been declining for many years, due in large part to the failure of business and government to invest. However, universities have been increasing their commitment. The result has been a mismatch between university investment priorities and the priorities of business and industry to deliver products and services based on internationally competitive leading-edge research and invention.

Universities have done a fantastic job of investing in health and medical research that has delivered new products and services in medical devices, pharmaceuticals, and vaccines. It has placed Australia in a good position to confront the current health crisis. It is time to think about a similar result for Engineering and Technology.

A revitalisation of investment in technology and engineering is essential to address the challenge in moving to new sources of growth.

To create the future, we must address and close the policy gaps. Numerous funding programs and cross-cutting Ministerial and Commonwealth-State responsibilities means that we do not currently have any semblance of an industrial strategy or coherent innovation policy. There is some support for sector-based strategies and innovation district initiatives – but the commitment is weak across Government, and expenditure is reported "after the event" instead of being driven by clear missions, objectives, and outcomes.

To recover from the present health and economic crises we must develop an industrial strategy and innovation policy that can move Australia to a post-carbon future, we must draw on Australian responses to previous crises, such as the Post War Reconstruction commitment, and avoid the policy failures surrounding responses to previous crises such as the 1974 oil shock, and the restructuring of the economy required after the removal of industry protection regimes and introduction of microeconomic reforms in the early 1990s.

In particular, we must:

1. *Make a commitment to a national industrial strategy* with a new body charged with responsibility for the development and implementation of a national industrial strategy and innovation policy, with a remit to identify, plan, and commit to specific national missions. It could be referred to as the *National Industrial Strategy and Innovation Commission*. The present Productivity Commission would advise the new Commission on specific micro-economic issues.
2. *Develop and adopt a consistent and coherent policy framework* across all agencies with an industrial policy remit to put an end to the fragmentation of programs across Ministerial portfolios, departments, and agencies. Policy must obtain high level cooperation and coordination with the States/Territories, respecting State/Territory roles and responsibilities, and their front line capacity for implementation and delivery.
3. *Make a sizeable RDI investment commitment in industrial sectors* critical to Australia's technology and innovation future: Energy (renewable particularly); Land, Water, and Climate Change; Transport, Communication and Infrastructure; and Industrial Production and Technology.

   Investment in each sector would be driven by four new *Research Investment Councils*. They would complement the investment mandates of the NH&MRC and the Rural RDCs. The ARC would continue to invest in the Humanities, Arts, and Social Sciences.
4. *Address workforce development, education, and training* imperatives to ensure that people can acquire both the high level occupational and academic skills required for industrial growth in the industries of the future. The small and mostly disconnected STEM training initiatives across the Commonwealth and States/Territories must be consolidated. The current high level of participation in Health education and training should be replicated in the Engineering and Technology fields.
5. *Secure a much higher level of university-industry collaboration* with a better match of research and innovation priorities supported by the Research Investment Councils and financial support for university-industry Engineering and Technology Research Institutes, drawing on the Fraunhofer framework.

6. *Support innovation place-making* through investment in nationally significant precincts, districts, and clusters that will facilitate the formation of high growth new technology businesses (start-ups) and scale up through smart specialisation strategies in global markets and value chains.

The health crisis and the current uncertain economic future provides the essential foundation for a National Recovery Plan that has Science, Research, and Innovation at its heart. But we can be assured that economic recovery will not be back to "business as usual". Industries that have collapsed, which have relied on low cost, casual, part-time, and unskilled workers, may never recover.

This Paper addresses the issues in the following Sections:

- An introduction that sets the scene, the problems and opportunities (Section 1)
- A detailed outline of the Challenges ahead (Section 2)
- The current Research, Development and Investment Climate (Section 3)
- Policy gaps, failures and opportunities (Section 4)
- Policy imperatives that must be addressed (section 5)
- Recommendations for new policy directions (Section 6).

1 Introduction

COVID-19, and the public health response, has created a national economic crisis. But it has also created an opportunity to transform the economy to new sources of growth.

Five growth factors have underpinned Australia's current economic prosperity:

- Growth in consumer demand, stimulated by an extensive net migration program and a high level of international tourists
- Growth in exports of resource-based commodities, particularly iron ore, coal, and natural gas
- Increase in the export of education services
- Increase in government expenditure on infrastructure (Commonwealth, State and Local)
- Increase in the level of manufacturing imports – sustained by the high level of exports.

Over the last two months consumer demand has collapsed contributing to the current economic crisis, and the export of education services is under stress. This has underscored the imperative to find new sources of growth.

1.1 Winds of change

There are already many warning signs on the horizon, and the risks to living standards of taking no action are recognised as being high. The fuels for a burning platform have been accumulating, albeit slowly. Already climate change and global warming are placing a cloud over the continuation of demand for our mineral fuels, particularly as countries and regions aim to achieve a net zero carbon[1] emissions target by 2050 – in thirty years' time. But with short-term political and news cycles, there has been little motivation to seriously address the longer term.

The COVID-19 pandemic has changed that. It has accelerated the need for structural adjustment as production and distribution systems change. The collapse of the global tourism industry provides a stark warning. Some sectors have been hit hard, such as retail, accommodation, travel, food service, sport and recreation, and the creative industries. Recovery will be tough and possibly accelerate changes that are already underway, such as online retailing and platform-based food, marketing, and travel services.

But other sectors are doing well, such as farming, food processing, health and medical services, front line public services, advanced manufacturing, and distribution and delivery of online purchases. The pandemic, and before that, the bushfire crisis, has helped us appreciate the value of people who work in front-line service and emergency services. Hopefully, we have recognised the error and the consequences of austerity and efficiency-driven cutbacks in these essential services.

[1] "Carbon" is shorthand for greenhouse gas emissions, including CO2, methane, nitrous oxide and F-gases. These gases are released by many different types of activity – not just the burning of fossil fuels, but also farming, deforestation and some industrial processes.

Services in a crisis do not respond well to Machine Learning, AI, Automation, and Robotics. They require humanity and compassion.

We do not know the extent to which the economic crisis created by the pandemic will stimulate a fundamental shift in patterns of consumer demand and industrial supply. But shifts are likely as demand recovers, enabled by a massive injection of government expenditure and the phasing down of lock-down regulations, and consumers continue to re-orient their wants and preferences towards low carbon products and services.

In contrast to the economic stimulus of 2008, the current package of stimulus measures provides little for new asset creation, particularly new knowledge assets. The injection of capital funds into the universities in 2008 has had a massive impact in lifting research capacity and capability, particularly in medical science. This time, and in setting pathways to new sources of growth, investments in technology and engineering research capability would be well made, and consistent with the strategies outlined in this Paper.

We do know from economic and industrial history that crises stimulate innovation and, in turn, call forward innovations in advanced technology and engineering.

The crisis of World War II for example, stimulated action to increase the supply of domestically produced goods and services to meet pent up consumer demand. A planning and capability response orchestrated by the Department of Post-war Reconstruction (formed in 1942), the 1945 Economic White Paper, and a group of talented public service development economists resulted in the “long boom” that continued until the oil shock of 1973.

Regrettably, the transition to a post tariff/post protectionist economy from 1973 was not well planned, and we are now likely to suffer the consequences for lack of prescience and preparedness for a low carbon economy.

This lack of preparedness has arisen notwithstanding the extensive “library” of economic policy statements and industry strategy papers that have been commissioned and released from that time. The failure of policy is documented in Attachment 3 “Evolution of Australian Industry and Innovation Policy”.

The present crisis provides an opportunity to re-align the public science and research system with the opportunities for industrial innovation and growth in a post-carbon economy. The present lack of alignment, or mismatch, between public science (mainly carried out in universities) and industry innovation (carried out in business) is a major focus of this Paper. A quantum lift in investment in Technology and Engineering research is a precondition for finding new sources of growth.

A major investment in Technology and Engineering would be a foundation plank in a ***National Recovery Plan*** for economic and industry renewal as the pandemic subsides, and the damage to the economy becomes apparent, and the opportunities and potential strengths are revealed.

1.2 Towards new sources of growth

We need not repeat the policy failures of the past. Australia can seize the opportunity created by the disruption of the COVID-19 pandemic to start seriously investing in new sources of growth to guide us into a post carbon industrial framework. This will require a clearly articulated long term and visionary industrial strategy and national innovation policy that commences with a step change commitment to investment in Science, Research, and Innovation (SRI).

New investments in growth opportunities will require moving away from sources of growth associated with exploitation of mineral fuels, and heavy utilisation of those fuels, including energy production, building and construction, and transport and travel, to industries adopting and applying "New Industry" technologies – autonomous systems, big data and analytics, sensing and robotics, visualisation, and renewable energy sources. But the build-up of compassion and humanity that has come out of the pandemic must be retained through the adjustment processes.

There has already been a strong and growing pressure from within business and the community to reduce Australia's dependence on coal and other mineral fuels to achieve a target of zero net carbon emissions in Australia by 2050. There is, of course, an entrenched and vocal group more comfortable with the *status quo.* But satellite images of big polluting cities before and after the onset of the pandemic and industry lockdowns provide the stark reality of what life might look like in a post-carbon future.

Pressure is also mounting to reduce reliance on international tourism as a growth driver. Greater pressure on the tourism industry is likely as governments introduce *human* health safety checks on international travellers in a similar regime to biosecurity and food safety inspections administered by the former Australian Quarantine and Inspection Service (AQIS). In the future, the international cruise industry is likely to be much more tightly regulated from a health risk perspective.

This may be opportune. Cruise ships and aircraft are heavy users of carbon fuels. The pressure of tourism on metropolitan infrastructure is raising concerns, as is the environmental impacts in both cities and regions. Economists are well paid to extol the benefits in terms of "big numbers", but now closer examination is being given to the costs – costs of crowding, asset degradation, and provision of new public infrastructure. But this creates sensitivities, as the industry is a substantial employer of unskilled casual and part-time workers. Moderation must be embedded in the way forward.

A serious and sustained commitment to technical skills development and training for displaced unskilled workers in the holiday economy can provide an opportunity for this cohort to work in the high technology "knowledge" jobs that will be required in the transition to new sources of growth. Already, technical skills are in short supply in growing technology-driven industries and, continued reliance on the 482 TSS visa scheme is not a serious option. We all have a responsibility to raise the education and training aspirations of this group.

Achieving net-zero emissions target by 2050, and the adjustments that will be required in the structure of the economy is sufficiently important for Australia's future to be adopted as a national mission.

Above all, we need to reinvent manufacturing ("making things") as a high technology industry and disrupt the current policy model that reflects a historical path dependency, a protectionist "hangover", an aversion to "picking winners", and address *system* failures. Market-based resource allocation mechanisms are important, but they must be guided by a *visible hand* that provides leadership and supporting investments in expensive next-generation infrastructure (including broadband), scientific discovery to create new knowledge and the creation of new technologies that capture the opportunities created by the digital revolution.

1.3 A national mission

Countries and regions are increasingly embracing missions to guide investment, technology development, and resource allocation. Getting a Man on the Moon is probably the most well-known and popularly used anecdote. Like winning a battle (or war), the path towards achieving a mission requires plans (strategies) and tactics. It involved pulling through previously unthought-of technologies, which were, in turn, widely taken up in industry. Think Teflon.

Achieving *a national mission for net-zero carbon emissions* will require the development of industrial strategies that focus on developing the potential for new sources of growth – new jobs in new industries and in industries that will be transformed by technology.

The impact and post-adjustment to COVID-19 provides a space to think about that. Some of those industries will be brand new, while others might be extensions of existing ones, and some might involve the reconstruction of industries decimated by the flood of imports that followed the removal of tariff protection, or the failure to compete effectively on a global stage – such as agriculture.

A national mission is both a set of challenges as well as a statement of intended achievement. Of course, a national mission is a little hollow if there is little commitment to developing the instruments of how to get there. Fundamentally, one of those instruments is new investment in Science, Research, and Innovation.

Long term Science Research and Innovation Strategy policies must support the technological breakthroughs and changes that will be required for the transformation of currently high carbon-emitting industries – such as transport, electricity production, residential and commercial buildings, and agriculture – to lower carbon footprints. It means innovation – not continuous or incremental improvement.

Strategy development and design of implementation frameworks takes time. Moreover, design must be sufficiently agile, responsive, and flexible to changing internal and external constraints and opportunities – particularly when looking at a 30-year time frame.

SRI strategies must stimulate the new scientific discoveries that will provide the foundations for technological breakthroughs. They must also provide the investments in education and training that will build the skills, knowledge, and capabilities in applying new technologies in new jobs in new industrial processes.

The capacity to create new technologies means reversing the trend decline in business and government investment in SRI capability that has occurred over the last 20 years

Strategy must also build commitment and engagement across the three main research performing sectors of the economy – business, universities, and government (and specifically, government research agencies). In Australia, Government commitment is captured principally in the CSIRO. Most attention is required for sustained improvement in business-university engagement.

1.4 Business-university engagement

We might be able to take some comfort from the *trend increase* in university commitment to SRI research. However, this has been sourced precariously from growth in student fees and accumulated internal funding. Moreover, the current direction of university SRI investment reflects a significant mismatch between the priorities of university research and the purposes identified by Australian industry for new knowledge and technologies.

The fundamentally different missions of universities and industry create a challenge for effective engagement and collaboration between the two sectors.

Public pronouncements indicate that both sectors would like to be closer. This means that the two sets of institutions must understand the barriers to, and the opportunities for productive collaboration - including the role of universities in building national and regional innovation capability in both existing firms and in high potential start-ups, and the obligation of business to deliver a return on investment.

Governments cannot mandate collaboration and engagement, but they can invest in building the frameworks for long term partnerships. This has not been happening. Both universities and business consider that national government SRI policy has been failing in this endeavour.

Government SRI policy at the national level has been characterised by program gaps and discontinuities and a lack of commitment over a considerable period. Apart from the Cooperative Research Centre (CRC) program, there is no consistent long-term policy framework to drive collaboration between business and universities – and even here, the focus of the program has shifted many times. Many programs have been too small, and too short term, to make a difference.

The Commonwealth commitment to SRI has declined (in inflation-adjusted terms) from $10,639m in 2011-12 to $9,493m in 2019-20 a fall of 10.8% over eight years.

State and Territory governments have stepped in to fill the gap, commencing with the Queensland Smart State Program and the Victorian Science, Technology and Innovation initiative at the beginning of the century. These were heavily concentrated in the health and biosciences fields. Queensland commitment continues with the *Advance Queensland* initiative. Other governments have an interest but invest very little. There is also an element

of opportunism as States look to developing their own Defence, Space, and Cybersecurity industries.

1.5 A new national approach to SRI strategy and resourcing

The current approach to industrial strategy is nether mission-oriented or strategic. It is an aggregation of largely disconnected funding programs, policy documents, and announcements. There is a surfeit of glossy publications containing highly rendered images, photos of Ministers, stock images of cross-cultural people in white coats, aspirational phraseology, some big numbers, colourful charts - and overall slick presentation.

Some of the more serious efforts at strategy development are reflected in the *Australia 2030* Innovation Strategy and the National Science Statement of 2017[2]. The Government's vision for science, set out in the National Science Statement, covers:

- Engaging all Australians with science
- Building our scientific capability and skills
- Producing new research, knowledge and technologies
- Improving and enriching Australians' lives through science and research

The Statement indicates that Government's support is provided by "funding and other resources for the spectrum of basic to applied scientific research, critical scientific infrastructure and equipment, and science and mathematics education, directly investing in Australia's future". The approach to implementation and delivery is very much "hands off":

> Through coordination and governance arrangements such as the National Science and Research Priorities, the government will continue to set strategic direction and priorities for Australian science. Along with advice from the Chief Scientist and bodies such as the Commonwealth Science Council and Innovation and Science Australia, this coordination will help shape the research that is carried out, delivering the outcomes and applications that tackle national and global challenges and take advantage of Australia's unique opportunities. Coordinated strategic action will also build awareness of systematic strengths and gaps in Australia's scientific capabilities[3].

The way in which the current Australian Science and Research priorities link to the development of Australian industry – or an Industrial Strategy – is at best uncertain.

In 2019 the Government reported in the annual publication, *Science, Research and Innovation (SRI) Budget Tables*[4] there were 139 separate Commonwealth SRI assistance or support programs unevenly spread over 14 Socioeconomic Objectives (SEOs). The allocation of 2019-20 budget expenditure is shown in Table 1.

[2] https://publications.industry.gov.au/publications/nationalsciencestatement/index.html
[3] https://publications.industry.gov.au/publications/nationalsciencestatement/index.html
[4] https://www.industry.gov.au/data-and-publications/science-research-and-innovation-sri-budget-tables

Table 1: Commonwealth Budget SRI allocated to Socioeconomic Objectives

SEO Category	Number of Programs	2019-20 Budget Expenditure ($m)	Proportion of total
00. Multiple categories[1]	**10**	4,337.7	**45.0%**
01. Exploration and exploitation of the Earth	**3**	130.7	**1.4%**
02. Environment	**7**	53.1	**0.6%**
03. Space	**1**	42.8	**0.4%**
04. Transport, comms, other infrastructures	**3**	2.6	**0.0%**
05. Energy	**4**	235.5	**2.4%**
06. Industrial production	**7**	238.9	**2.5%**
07. Health	**36**	1,412.9	**14.7%**
08. Agriculture	**23**	479.5	**5.0%**
09. Education	**0**	0	**0.0%**
10. Culture, recreation, religion and mass media	**0**	0	**0.0%**
11. Political and social systems	**23**	48.1	**0.5%**
12. General advancement of knowledge	**12**	2,177.5	**22.6%**
14. Defence	**10**	**476.5**	**4.9%**
	139	**9,635.8**	**100.0%**

1.Includes R&D Tax Incentive, CSIRO, ANSTO, GeoScience Australia, AIMS, Met Bureau, ARC, National Collaborative Research Infrastructure.
Source:

There is a loose connection between the SEO categories and the National Science and Research priorities, which cover nine functional areas:

- Food, Soil and water (08 Agriculture and 06 Industrial Production)
- Cybersecurity
- Energy (05 Energy)
- Resources (01 Exploration and Exploitation of the Earth)
- Advanced Manufacturing (06 Industrial Production)
- Environmental Change (02 Environment)
- Health (07 Health)

Table 1 indicates that *45%* of the science budget is allocated to "Multiple categories" and *22.6%* to General Advancement of Knowledge - where objectives are, in effect, determined by the strategic priorities of the agencies concerned, including universities. These allocations would be expected to take account of the National Science and Research priorities[5]. With the exception of Health and Agriculture, the budget allocations to specific industry categories are exceptionally small.

Table 1 would suggest that the RDI for industries that will be important for achieving new sources of growth are grossly underfunded – particularly Industrial Production, Energy (specifically renewable energy), the Environment, and Transport, Communication and Infrastructure.

However, the classification indicates that expenditure associated with many of the SEOs that are potentially important for a transition to new sources of growth are seriously underfunded with commitment to many appearing to be uncoordinated across Ministerial Portfolio responsibilities.

1.6 New investment and resource allocation frameworks

It is of note that the industries with the highest SRI investment commitment are the ones supported by specific and long-standing resource allocation frameworks. Others have suffered

[5] See https://www.industry.gov.au/data-and-publications/australias-national-science-statement

from austerity-driven budget cuts and very short-term program commitments. Two resource allocation frameworks have achieved significant success in building RDI capability and industry performance:

- Health and Medical Research – through the NH&MRC, the MRFF, Philanthropy, and State government initiatives
- Agriculture – the Rural Research and Development Corporations (and a successor organisation that addresses cross-sectorial research and innovation).

These frameworks provide models for the industries that will be expected to lead in transitioning to new sources of growth.

Research in the SEOs that are important for the transition to new sources of growth should be strongly supported by a substantial and targeted increase in commitment and financial investment by Government, Business, and Universities working collaboratively.

The allocation of that commitment should be mission-driven, strategically directed, coordinated, and assigned through four new formally constituted Research Investment Councils that would cover:

- Energy – particularly renewable energy and energy innovations including hydrogen;
- Land, Water, and Climate Change – to take a serious research and evidence-based commitment to the protection, preservation, and restoration of our natural capital as a basis for addressing the net zero emissions target
- Transport, Communications and Infrastructure - to address the urgent need for RDI in the context of change and disruption that is occurring in these industry sectors
- Industrial Production and Technology – science, research, and innovation to discover new knowledge and develop technologies in new industry categories.

The Councils would take on similar roles to the NH&MRC and the Rural Research and Development Corporations. The role of the Australian Research Council would continue to drive strategy in the Humanities, Arts and Social Sciences.

The work of the Councils would be coordinated by a Ministerial Council on Science, Research, and Innovation. The Councils would include Ministers with Portfolio responsibility for the Councils together with Ministers responsible for the ARC (Education), the NH&MRC (Health), the Rural RDCs (Agriculture) and Defence Innovation.

This Paper provides a detailed analysis of the background relating to our current predicament and enlarges on ways to set a direction for sustained growth in a carbon-neutral industrial structure created by the opportunity of the COVID-19 crisis.

2 The challenge ahead: finding new sources of growth

Australia has enjoyed a prolonged period of economic growth, which has created jobs, raised living standards and funded expansion of health and education services. However, serious economic commentators and innovation analysts would argue that continued success is very far from assured.

This has come to an end with the onset of the COVID-19 pandemic, the disruption created by the public health response, and the instability introduced into the structure of employment, incomes, and growth opportunities.

2.1 The problem

The problem for Australia in a post-mining boom context has been for some time, "How to transition to new sources of growth as commodity prices and investments in resources projects normalise" (Lydon et al., 2014, Green and Howard, 2015a, Green and Howard, 2015c, Green et al., 2012). But the question has not taken on the urgency that might be expected. This may reflect some confidence that the mining boom will continue for some time to come - but pressures are mounting with the increasing groundswell of opinion supporting a commitment to net-zero carbon emissions by 2050.

New sources of growth will be the outcome of a national commitment to research, development and innovation (RDI) to revitalise the performance of existing industries and the evolution of new ones.

Prescience and preparedness through RDI must be key planks in Australia's industrial strategy and innovation policy.

In 2018-19 Australia's exports of goods and services amounted to $469.9 billion, representing 24.1% of GDP[6]. The top 25 exports for the years 2016-17 to 2018-19, which amount to 79% of all exports are listed in Table 2 below.

Table 2: Australia's top 25 Exports, goods and services (a)

Rank	Commodity	2016-17 $m	2017-18 $m	2018-19 $m	2018-19 % share		Growth 2017-18 – 2018-19 %	5-year growth trend (%)
	Mining and mineral fuels							
1	Iron ores & concentrates	62,617	61,392	77,189	*16.4*		*25.7*	*2.3*
2	Coal (c)	54,236	60,379	69,592	*14.8*		*15.3*	*14.1*
3	Natural gas	22,308	30,907	49,731	*10.6*		*60.9*	*23.7*
6	Gold	18,979	19,293	18,867	*4.0*		*-2.2*	*8.8*
7	Aluminium ores & conc (incl alumina)	7,529	9,448	11,358	*2.4*		*20.2*	*12.4*
9	Crude petroleum	5,150	6,506	8,491	*1.8*		*30.5*	*-4.8*
10	Copper ores & concentrates	4,577	5,700	5,936	*1.3*		*4.1*	*2.5*
16	Aluminium	3,272	4,096	4,251	*0.9*		*3.8*	*1.2*
17	Copper	3,128	2,891	3,968	*0.8*		*37.3*	*-0.7*
20	Other ores & concentrates	2,602	3,140	3,554	*0.8*		*13.2*	*-7.4*
23	Refined petroleum	2,347	2,626	3,005	*0.6*		*14.4*	*1.9*
					54.4			
	Rural production							
8	Beef, f.c.f.	7,115	7,963	9,476	*2.0*		*19.0*	*4.0*
12	Meat (excl beef), f.c.f.	3,831	4,526	5,152	*1.1*		*13.8*	*8.0*
18	Wool & other animal hair (incl tops)	3,263	3,985	3,815	*0.8*		*-4.2*	*10.2*
19	Wheat	6,073	4,652	3,657	*0.8*		*-21.4*	*-7.9*
					4.7			

[6] https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5204.02018-19?OpenDocument

Rank	Commodity	2016-17 $m	2017-18 $m	2018-19 $m	2018-19 % share		Growth 2017-18 – 2018-19 %	5-year growth trend (%)
	Manufactured products							
21	Alcoholic beverages	2,612	3,111	3,374	*0.7*		*8.5*	*11.2*
24	Pharm products (excl medicaments)	1,317	1,583	2,953	*0.6*		*86.6*	*41.3*
25	Edible products & preparations, nes	2,524	3,007	2,943	*0.6*		*-2.1*	*27.1*
					1.9			
	Services							
4	Education-related travel services (d)	28,093	32,602	37,556	*8.0*		*15.2*	*15.2*
5	Personal travel (excl education) services	21,628	21,332	22,450	*4.8*		*5.2*	*5.8*
11	Professional services	4,943	5,196	5,626	*1.2*		*8.3*	*3.5*
13	Telecom, computer & information services	3,332	4,219	5,081	*1.1*		*20.4*	*14.6*
14	Financial services	3,965	4,569	4,933	*1.0*		*8.0*	*7.4*
15	Technical & other business services	4,511	4,436	4,662	*1.0*		*5.1*	*5.9*
22	Passenger transport services (e)	2,833	2,936	3,075	*0.7*		*4.7*	*5.4*
					17.8			
	Total – all exports (b)	**373,769**	**403,360**	**470,170**			***16.6***	***7.4***
	Education (g)	28,604	33,197	nya	..		..	..
	Tourism Satellite Account	34,561	37,200	nya	..		..	..

(a) Goods trade is on a recorded trade basis; Services trade is on a balance of payments basis. (b) Balance of payments (BOP) basis. (c) Includes BOP adjustment. (d) Includes student expenditure on tuition fees and living expenses. (e) Mainly of Lead, Zinc and Manganese ores & concentrates. (f) Includes Related agency fees & commissions. (g) Includes Education-related travel services, Royalties on education services and Other education services.

nya = not yet available; f.c.f. - fresh, chilled, frozen

Based on ABS trade data on DFAT STARS database and ABS catalogues 5368.0 (Sep 2019) & 5429.0.

https://www.dfat.gov.au/sites/default/files/australias-goods-services-by-top-25-exports-2018-19.xlsx

Table 2 shows that the *five-year* trend growth in exports to 2018-19 has been 7.4%, but between 2017-18 and 2018-19, exports grew by 16.6%. This growth has been driven by a boom in mining and mineral fuels exports, due to increased volumes and high commodity prices. In 2018-19, 54.4% of exports were mining and mineral related, contributing 13.1% to GDP. Just three commodities (iron ore, coal, and natural gas) contributed almost 42% to exports.

This position reinforces the question about transition.

2.2 Finding the opportunities

- It is widely acknowledged that mineral fuels have a limited future as an energy source and iron ore exports are contingent largely on future trends in the Chinese economy.
- Unprocessed agriculture exports are subject to strong competition from developing nations and the emergence of substitutes (plant-based protein as a replacement for meat, for example).
- Drought and climate change will have long term impacts on capacity to produce at current volumes, and ethical concerns and social license to operate will also have an impact.

Australia relies heavily on the current boom in mining and mineral fuels for our current prosperity. With many countries moving to a position of net-zero carbon emissions and switching to renewable energy sources, it is unrealistic to think that the boom will continue.

As a nation, and as an economy, it would seem highly unlikely that we can rely indefinitely on commodity exports to underwrite our economic future. The dramatic decline of Australia's wool export market is a salutary example that things can go wrong (Massy, 2011).

At the same time, there are remarkable opportunities for Australian firms to export more manufactured final and intermediate goods, as well as value-added knowledge-intensive

services, to meet the needs of the global market, particularly Asian end-users. This means active participation in global value chains. But here again, Australia enjoys no guarantee of success.

There are also opportunities to address the exceptionally large volume of imports into Australia through "re-shoring" and de-risking reliance on some aspects of global supply chains. In 2018-19 Australia imported goods and services to the value of $421.4 billion, up by 6.5% over the previous year. The top 25 import categories are listed in Table 3 below.

Table 3: Australia's top 25 imports, goods and services, (a) (b)

Rank	Commodity	2016-17 $m	2017-18 $m	2018-19 $m	2018-19 % share		Growth 2017-18 – 2018-19 %	5-year growth trend (%)
	Mining and mineral fuels							
12	Gold	7,240	6,540	5,517	*1.3*		*-15.6*	*7.6*
2	Refined petroleum	17,389	21,688	25,083	*6.0*		*15.7*	*5.7*
5	Crude petroleum	8,574	11,738	13,412	*3.2*		*14.3*	*-8.1*
					10.5			
	Manufactured products							
3	Passenger motor vehicles	21,782	23,299	21,574	*5.1*		*-7.4*	*4.7*
4	Telecom equipment & parts	11,969	13,412	14,590	*3.5*		*8.8*	*8.9*
6	Goods vehicles	8,004	10,181	10,571	*2.5*		*3.8*	*13.4*
8	Computers	7,854	8,837	9,763	*2.3*		*10.5*	*5.5*
14	Civil engineering equipment & parts	2,879	4,244	5,085	*1.2*		*19.8*	*10.1*
11	Medicaments (incl veterinary)	7,340	7,169	7,481	*1.8*		*4.4*	*-0.4*
16	Furniture, mattresses & cushions	4,203	4,497	4,990	*1.2*		*11.0*	*6.5*
18	Pharm products (excl medicaments)	3,931	4,283	4,842	*1.1*		*13.0*	*15.6*
20	Electrical machinery & parts, nes	3,383	3,693	3,960	*0.9*		*7.2*	*6.0*
21	Plastic articles, nes	3,292	3,550	3,863	*0.9*		*8.8*	*7.6*
22	Household-type equipment, nes	3,330	3,346	3,664	*0.9*		*9.5*	*6.5*
23	Measuring & analysing instruments	3,038	3,256	3,641	*0.9*		*11.8*	*2.4*
24	Prams, toys, games & sporting goods	3,207	3,322	3,517	*0.8*		*5.9*	*5.4*
25	Medical instruments (incl veterinary)	2,946	3,268	3,412	*0.8*		*4.4*	*8.0*
					23.9			
	Services							
1	Personal travel (excl education) services	37,731	42,684	46,343	*11.0*		*8.6*	*7.2*
9	Professional services	6,123	6,657	7,775	*1.8*		*16.8*	*7.7*
7	Freight transport services	8,429	9,428	10,114	*2.4*		*7.3*	*-0.3*
10	Passenger transport services (d)	6,789	7,139	7,534	*1.8*		*5.5*	*3.8*
13	Technical & other business services	4,739	5,168	5,457	*1.3*		*5.6*	*-3.0*
15	Charges for the use of intellectual property nie	4,304	4,625	4,996	*1.2*		*8.0*	*2.5*
17	Telecomms, Computer & information services	3,559	4,253	4,878	*1.2*		*14.7*	*10.7*
19	Business travel services	4,176	4,208	4,296	*1.0*		*2.1*	*2.7*
					21.7			
	Total – all imports(c)	362,898	395,645	421,394			*6.5*	*4.1*
	Education (e)	515	452	nya	..		..	..
	Tourism Satellite Account	46,766	48,610	nya	..		..	..

(a) Goods trade is on a recorded trade basis, Services trade is on a balance of payments basis. (b) Please note – imports of aircraft were made confidential by the ABS from Sep-08 onwards. Imports of aircraft would be ranked in Australia's top 25 imports in 2018-19 estimated to be valued at around $4.6bn. (c) Balance of payments basis. (d) Includes Related agency fees & commissions. (e) Education includes Education-related travel services, Royalties on education services and Other education services.

nya = not yet available; nes - not elsewhere specified.

Based on ABS trade data on DFAT STARS database and ABS catalogues 5368.0 (Sep 2019) & 5429.0.

Source: https://www.dfat.gov.au/sites/default/files/australias-goods-services-by-top-25-imports-2018-19.xlsx

2.3 Reinventing manufacturing

Table 3 indicates that Manufacturing imports accounted for almost a quarter (23.9%) of imports. Two-thirds of Australia's total imports in 2018-2019 were purchased from ASEAN countries. European trade partners accounted for 19.2% and 12.3% from the United States[7].

[7] https://www.dfat.gov.au/sites/default/files/australias-goods-services-by-top-15-partners-2018-19.xlsx

Many of Australia's largest import categories are manufactured items that were once produced from a robust, but highly protected Australian manufacturing industry.

The failure of Australian manufacturing to adjust to the forces of global competition with the removal of protection in the 1990s, and the inefficient use by international corporations of transition subsidies and investment incentives, have reduced manufacturing capacity, with consequent impacts on jobs. There are, of course, some exemplars in what might be referred to as high technology manufacturing, particularly where businesses have made the transformation to high technology applications and global operations [eg. Visy, BlueScope, Austal].

There are many initiatives underway to build an Australian high technology and advanced manufacturing sector that draw on "new industry " technologies such robotics, AI, additive manufacture, advanced materials, and micro processing. But research commitment is low and government support short term and more tactical, and even opportunistic, rather than strategic.

Advanced, technologically oriented, manufacturing will be vital for Australia's future economic prosperity.

It is not as if this aphorism has not been made in the past – in fact consistently over the last 30 years. But the embedded policy model makes change difficult, if not impossible, to accomplish.

2.4 Disrupting the current policy model

There are several features of the industrial strategy policy model that must be addressed and removed if a transition to new sources of growth has any chance of coming to fruition.

2.4.1 Path dependency

It has long been argued that growth will not come automatically to Australia, and we must make an effort to change. But the current policy model has a "path dependency" embedded in our economic and industrial history. It is reflected in our political culture, which provides a solid bulwark against the introduction of change and setting new directions. There is a sense that all is OK, and current economic and social frameworks will continue unabated.

With globalisation, unprecedented technological breakthroughs around biomedical and digital technologies, the rapid economic growth of emerging economies, and the impacts of climate change, this do-nothing complacency is very risky. In the language of change management, there has been no "burning platform". Ironically, perhaps the recent devasting bushfires and the impact of drought might spark policy-makers into action.

Just over 20 years ago David Mortimer issued his report *Going for Growth* (Australia. Review of Business Programs, 1997)[8] and three years later the Chief Scientist added *The Chance to Change* (Australia. Chief Scientist (Dr Robin Batterham), 2000), coinciding with the National Innovation Summit, which led into a series of policy statements themed on *Backing Australia's Ability* (Australia. Prime Minister, 2001, Australia. Prime Minister, 2004). Very little in the way of tangible results can be attributed to these initiatives (new private investment, new business formation, or new jobs).

The themes and priorities urged on policy-makers at the beginning of the 21st century have been repeated in "libraries" of policy papers, reports, and Ministerial statements ever since. Many are simply a restatement of previous positions accompanied by a strong element of "spin". Perhaps the impact is expected in the announcement, with its attendant short term media profiling, rather than a commitment to achieve planned, accountable and measurable results.

So, what's holding us back – inertia, complacency, disbelief, policy failure?

It's probably a combination of all of these factors as Australia's economic history had been built around primary production and *industrial policies of import replacement behind a high tariff barrier* as an element of Australian post-war reconstruction - rather than policies directed towards *value-added export and participating global markets and value chains*. The "disruption" that occurred with the removal of tariff protection in the 1980s and 1990s was, in retrospect, not managed as well as it could have been – at the firm, industry, or policy levels.

2.4.2 The protectionist hangover

Companies that had grown behind the tariff wall with exceptionally high effective rates of protection such as textiles, motor vehicles, shipbuilding, white goods, and steel did not, in general, innovate and diversify with inevitable consequences for their long-term survival. Some did, of course, such as Visy, BlueScope, and Orica, and have now become global operations and brands.

Similarly, rural production has suffered from the culture of "agrarian socialism" that involved regulation, statutory marketing, guaranteed pricing arrangements, and privileges (subsidies) for farmers – all of which were antithetical to innovation. Rural innovation is now very much in "catch-up" mode with global trends and technologies and availability of risk capital, which is currently only trickling into Australia.

By contrast, industries that operated without protection such as mining technologies thrived and new manufacturing (making extensive use of R&D, design, simulation, automation, quality

8 1997 was also a year that marked the release of many landmark texts and profiles on industrial innovation – for example Zell, D. (1997). Changing By Design: Organizational Innovation at Hewlett-Packard; Tushman, M. L., & O'reilly, C. A. (1997). Winning Through Innovation: A Practical Guide to Leading Organizational Change and Renewal; Tidd, J., Bessant, J., & Pavitt, K. (1997). Managing Innovation: Integrating Technological, Market and Organizational Change; Stokes, D. E. (1997). Pasteur's Quadrant: Basic Science and Technological Innovation; Quinn, J. B., & Zien, K. A. (1997). Innovation Explosion: Using Intellect and Software to Revolutionize Growth Strategies; Pisano, G. P. (1997). The Development Factory: Unlocking the Potential of Process Innovation - Lessons from Pharmaceuticals and Biotechnology; Kim, L. (1997). Imitation to Innovation: The Dynamics of Korea's Technological Learning; Kao, J. (1997). Innovation: Breakthrough Thinking at 3M, DuPont, GE, Pfizer, and Rubbermaid ; Freeman, C., & Soete, L. (1997). The Economics of Industrial Innovation - 3rd Edition; Christensen, C. M. (1997). The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail.

systems, customer focus, and other innovations) thrived in the global context. In line with Christensen's disruption concept (Christensen, 1997), new entrants have embraced new market opportunities and have grown substantially. Older companies have changed substantially. In Australia, many of these companies were, and still are, privately owned, allowing for a much more committed long-term focus and growth strategy.

2.4.3 It's not about "picking winners"

Australian industrial strategy and innovation policy has reflected an ongoing tension between proponents of activist national and sector-based strategies on the one hand and public service free-market economists who have eschewed any idea of "picking winners" on the other.

There is still a very strong view within the Australian Government that industrial strategy and innovation policy should be principally confined to cases of "market failure". This is slowly giving way to some acceptance of a strategic approach.

Strategic approaches involve investigation, competitor analysis, benchmarking, market research, feasibility assessment, planning, financial modelling, and numerous other tools and techniques drawn from management practice. Of course, in the business world, "picking winners" based on sound strategy is *exactly* what happens. Picking too many losers puts the viability of a company at risk.

Boards do not run their businesses as free-market economies, although they do devolve responsibility and accountability to strategic business units, or lines of business.

In the context of a national industrial strategy in a large politically federated country like Australia, the US, and Canada, some degree of devolution to States/Territories and Regions is essential to address diversity in economic development realities and opportunities. While the concept of a *National Innovation System* can apply to unitary European States, the concept has a different application in Australia.

In Australia, the Commonwealth has a capacity to set national directions in the areas of income taxation (including deductions and incentives), Science, Research and Innovation Investment, and national R&D facilities (CSIRO, DSTO, ANSTO). These provide an important national innovation framework. However, States/Territories and Regions take on a role to set strategic directions that generally focus on creating jobs, that have regard to their own unique situations, circumstances, and strategic assets.

Most State/Territory Governments have developed their own industrial and innovation strategies, as have many regional cities and some regions.

The capacity for regional specialisation is behind long standing thinking about "clusters" and more recently *Regional Innovation Ecosystems*. Differences in regional attributes are at the basis of the Regional Smart Specialisation Approach that has been adopted in Europe and applied in several regions across Australia. There are many variations on the approach.

2.4.4 System failures

Institutional and policy differences between the Commonwealth and the States/Territories can give rise to "frictions" within the Australian National Innovation System.

However, there is a wide recognition that policy concerns should not be so much with market failure as they should be with *system failure*: the failure of key institutions in the research, development, and innovation system to interact efficiently and effectively (Dodgson et al., 2010), particularly interactions between business, research institutions, and government.

In Australia, the RDI system fails at the organisational and institutional[9] intersections between industry, research organisations and government. These institutions are fundamentally different in terms of mission, objectives, and routines. Perhaps reflecting an Australian short term transactional culture, *there has been a reluctance to seriously invest for the long term in building capacity and capability for business, university, and government institutions to engage efficiently and effectively*. The Cooperative Research Centres (CRC) Program is really the only successful long-standing commitment in this area.

RDI policies and programs, with the notable exception of the R&D Tax Incentive and CRC Program, have tended to be short term in nature (mostly 3-6 years), large in number, oriented around "funding" (albeit with very modest amounts of money), categorically defined, application and submission driven, rules-based, and subject to quick termination in the interests of fiscal austerity. However, large numbers of small programs are unlikely to be effective in achieving economic and industry outcomes (Mazzucato, 2015, Best, 2018). They are highly *transaction-oriented.*

If nothing else, the policy setting has established a wide choice of grants assistance programs and created a culture within many small to medium businesses of "growth through grants" - and generated a flourishing industry of grant writers.

It is perhaps a consequence of poor public policy, rather than the attributes of individual entrepreneurs that Australian businesses are regarded as poor innovators. Entrepreneurs have been *encouraged* to build businesses on the basis of subsidies and grants rather than selling more goods and services to customers. Grants intended to support ingenuity and inventiveness are seen as an entitlement. It is like "I have this idea … where can I get a government grant?"

There are of course numerous success stories that challenge this stereotype and are a cause for celebration. But perhaps we do not do this well enough, or systematically. The 2015 National Innovation and Science Agenda (NISA) was well-intentioned but failed to achieve traction with its messaging. The promised NISA 2.0 did not eventuate, with a constant revolving door of Ministers.

[9] Taken to mean a well-established and structured pattern of beliefs, attitudes, relationships, and behaviours that are accepted as a fundamental part of a culture: they are stable, valued, recurring.

2.4.5 The *Australia 2030: Prosperity through Innovation* initiative

A further attempt to disrupt the policy model is reflected in *Australia 2030: Prosperity through Innovation* (Innovation and Science Australia, 2017). This report found that Australian businesses have the *potential* to be innovative, but that realising such potential means addressing several challenges[10]:

- Encouraging more Australian businesses to achieve global best practice in innovative activity
- Getting greater economic and social benefits via more innovative procurement and service delivery performance of governments
- Developing an education system better able to meet the lifelong and changing needs of citizens and businesses
- Strengthening collaboration among our research and commercial sectors to increase innovation and commercialisation
- Maximising strategic international engagements to bring in the talent, knowledge and capital to fuel the innovation system
- Selecting high-impact projects capable of realising step changes in Australia's innovation outcomes out to 2030 and beyond

ISA considered that the biggest growth opportunities would come from knowledge intensive companies that innovate and export, as they are the most profitable, competitive, and productive.

ISA anticipated that such businesses would increasingly need to solve global problems at scale: "When they succeed, they will make a substantial contribution to new jobs growth in Australia". All the challenges point, in one way or another, to an imperative for greater private and public investment in research and innovation[11], and above all, stronger links between business and the national research and education system.

The problem to be addressed is that the linkages between business and the research and education system in Australia are reported to be some of the weakest in the world.

10These themes were of course addressed in 2001 and 2004 in the two Backing Australia's Ability Strategies AUSTRALIA. PRIME MINISTER 2001. Backing Australia's Ability: Real Results, Real Jobs, Canberra, Department of Industry, Science and Resources, AUSTRALIA. PRIME MINISTER 2004. Backing Australia's Ability: Building Our Future Through Science and Innovation, Canberra, Commonwealth of Australia., in 2008 in Venturous Australia AUSTRALIA. REVIEW OF THE NATIONAL INNOVATION SYSTEM (CUTLER REVIEW) 2008. Venturous Australia. Canberra: Department of Innovation, Industry, Science and Research., Powering Ideas AUSTRALIA. MINISTER FOR INNOVATION INDUSTRY SCIENCE AND RESEARCH 2009. Powering Ideas An Innovation Agenda for the 21st Century. Canberra: Commonwealth of Australia., the Asia in the Asian Century White Paper PRIME MINISTER 2012. Australia in the Asian Century: White Paper. Canberra: Government of Australia. the Rural Research and Development Policy Statement AUSTRALIA. MINISTER FOR AGRICULTURE FISHERIES AND FORESTRY 2012. Rural Research and Development Policy Statement. Department of Agriculture Fisheries and Forestry. Canberra: Commonwealth of Australia., the Industry Innovation and Competitiveness Agenda AUSTRALIA. MINISTER FOR INDUSTRY AND SCIENCE 2014. Industry Innovation and Competitiveness Agenda. An action plan for a stronger Australia., the Agricultural Competitiveness White Paper AUSTRALIA. MINISTER FOR AGRICULTURE. 2015. Agricultural Competitiveness White Paper Stronger Farmers Stronger Economy. Available: http://agwhitepaper.agriculture.gov.au/SiteCollectionDocuments/ag-competitiveness-white-paper.pdf., and the National Innovation and Science Agenda AUSTRALIAN GOVERNMENT 2015. National Innovation and Science Agenda: Welcomer to the Ideas Boom. Canberra: Australian Government.

11 *Going for Growth* advocated a target investment in R&D of 3% of GDP. It is currently 1.8%

Regrettably, the messages of the *Australia 2030* project are also passing into policy history. However, it is still a good starting point to pick up the theme of transitioning to new sources of growth.

2.5 The focus of this Paper

Against the background outlined above, this Paper addresses several potential causes of the weak links between universities and business and ways to resolve them as a basis for addressing the transition to new sources of growth. They centre on:

- Differing institutional settings and drivers between universities, business, and government
- A possible mismatch in priorities between university investment in research and those of business, particularly in production, engineering and technology that are vital for rebuilding Australia's manufacturing base
- Declining levels of government and business investment in research and innovation
- A dissipation of Commonwealth support for R&D across multiple programs and SEOs

The solutions will lie in:

- A significant and quantum leap by government and business in research and development in "new industry" areas – specifically around new and emerging technologies, including microprocessing and sensors, big data and analytics, robotics and automation, autonomous transport, nanomaterials, artificial intelligence, simulation, and visualisation, and energy capture, storage and transmission[12].
- Rolling up the plethora of categorical application/submission-based grant programs into a more substantial, strategically driven, long term, research and innovation agenda.
- Encouraging university research investment priorities to align more closely with the industrial strategy and innovation opportunities that focus on the new technology industries (robotics, automation, AI, etc).
- Creating more effective "institutions for engagement" between sectors.
- Creating Research Investment Councils to develop strategy, establish research investment criteria, allocate investment funds, and set the framework for accountability.
- Focusing industrial strategy on place-based innovation, around regions, districts, precincts, and hubs.

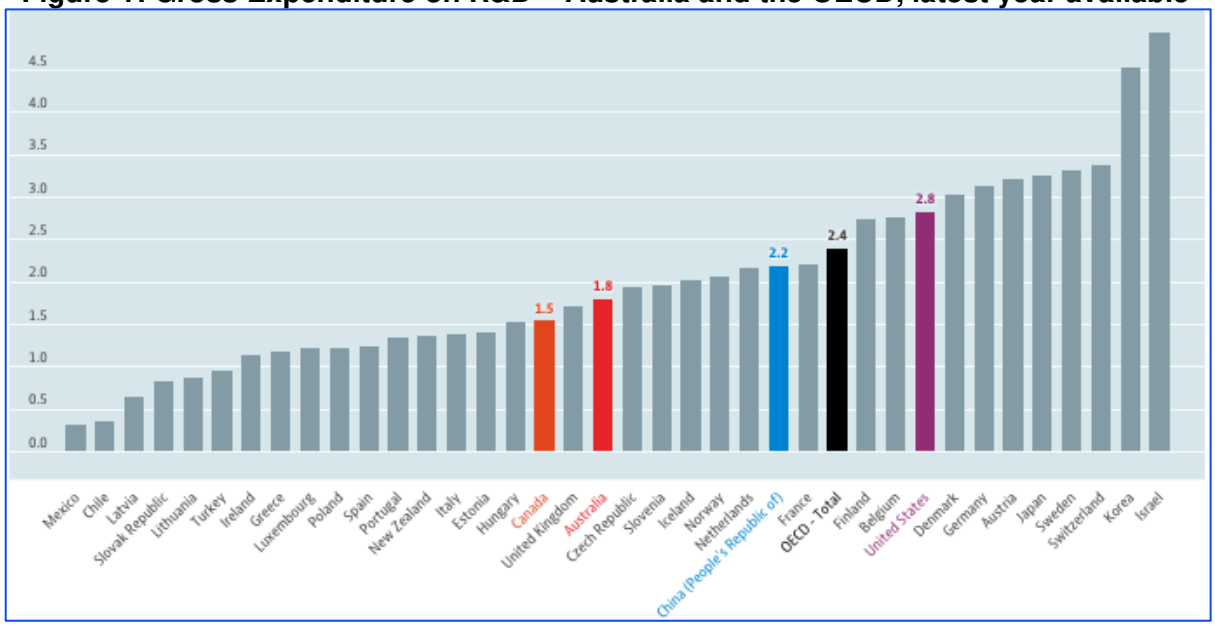
[12] These "new industry areas" are embedded across traditionally defined industries – represented by the ANZSIC industrial classifications or Science, Research and Innovation defined Socioeconomic Objectives (SEOs).

3 The research, development and innovation investment climate

3.1 What Australia invests in research and development

Based on the most recent data, Australia ranks poorly in terms of expenditure on R&D, amounting to a reported 1.8% of GDP (2017), compared to the OECD (2018) average or 2.4%, 2.19% for China, 2.83% for the US, and a massive 4.94% for Israel. A summary chart for all OECD countries is in Figure 1.

Figure 1: Gross Expenditure on R&D – Australia and the OECD, latest year available



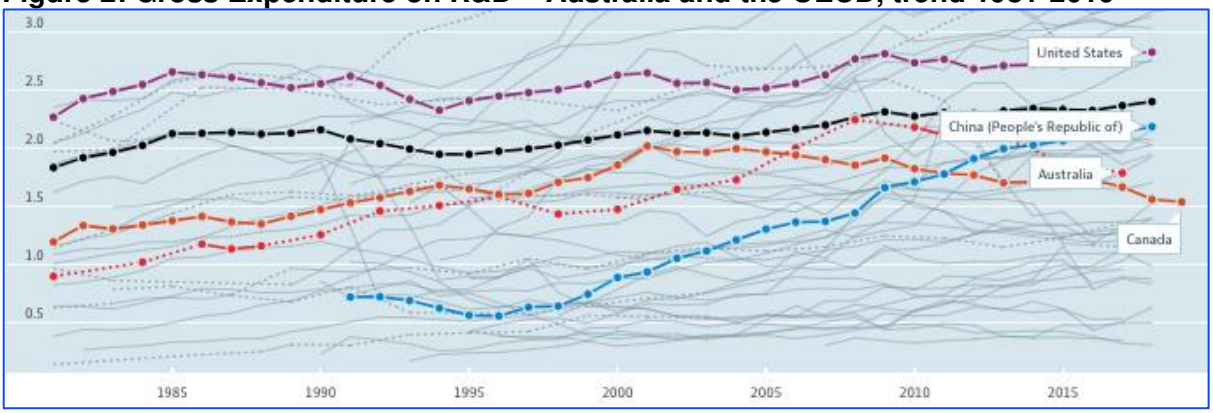
https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm?context=OECD

In terms of the long-term trend, the progressive increase in Australia's Expenditure on R&D as a proportion of GDP that started in 1981 faltered in 2008 when the proportion stood at 2.25% and as indicated, is now 1.8%. Comparative international trends over the period-1981 to 2019 are shown in Figure 2 below.

US Expenditure peaked in 2009 at 2.81%, following the GFC, but has recovered to 2.83% in 2018. Australian expenditure on GDP did not recover.

The rundown in R&D commitment since 2008 will have a severe impact on Australia's R&D capacity. The challenge is not only to reverse the downward trend but also to rebuild capacity.

Figure 2: Gross Expenditure on R&D – Australia and the OECD, trend 1981-2019

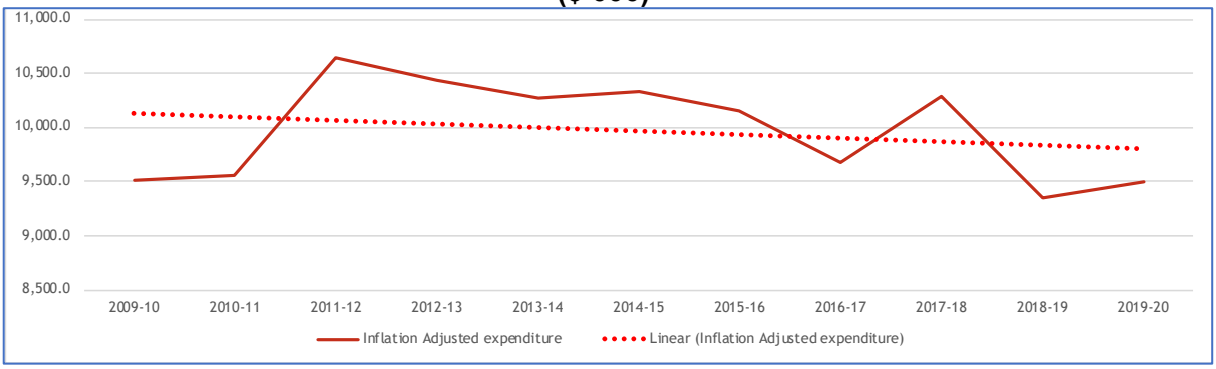


Source: https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm?context=OECD

A major explanation for the Australian decline is the reduction of business investment in R&D, which now stands at around one per cent. The reduction in business commitment is often attributed to a decline in the level of Government support for R&D, which peaked in 2011-12.

In 2014 Government support for R&D stood at 0.21% of GDP (20th in the OECD), having declined from 0.37% in 1995, 0.33% in 2000, and 0.27% in 2005 and 2010. Both the Commonwealth and the State governments have contributed to this decline with States particularly cutting back their investments in Agricultural R&D. But the Commonwealth has contributed most to the fall. The long-term trend is indicated in Figure 3.

Figure 3: Commonwealth support for SRI – Inflation Adjusted - 2009-10 – 2019-20 ($'000)



Source: Commonwealth of Australia, Science, *Research and Innovation Budget Tables, 2019-20*. Inflation-adjusted by applying the GDP deflator, included in the Table documentation.

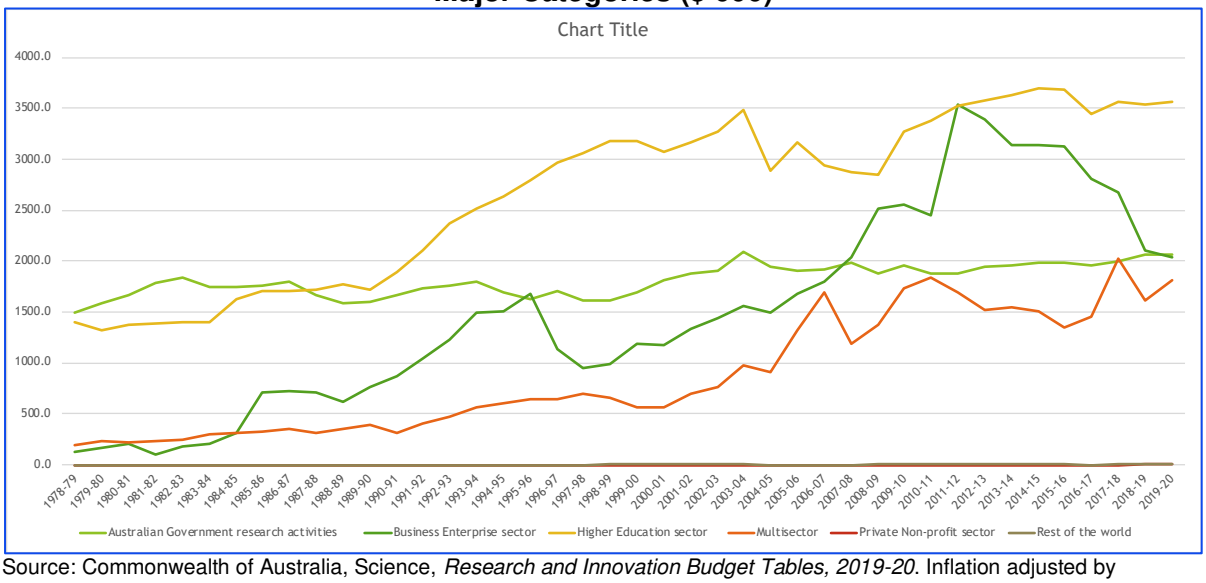
Commonwealth Government support for R&D peaked in 2011-12, where it stood at an inflation-adjusted $10.1 billion. It picked up for a short time in 2017-18 with the commitment to the Renewable Energy Agency, but has since fallen.

Information on Commonwealth support for R&D across sectors over the period 1978-79 to 2018-19 is provided in Figure 4, which indicates:

- A substantial increase in *support for Higher Education* R&D from 1988-89, peaking in 2003-04, reaching a low point in 2007-08, and subsequently increasing to a new peak in 2015-16.

- Support for *Business R&D* fluctuating widely - reaching a peak in 1995-96, then falling and recovering again in 1999-2000, from where it continued to increase until a new peak in 2011-12. It is now fallen back to a 2010-11 level.
- Support for Commonwealth research activities, principally CSIRO, reached a peak in 2003-04, falling away to a low in 2008-09, with minimal movement since. The decreasing commitment to CSIRO was accompanied by the expectation that the organisation would raise at least a third of its income from external sources.
- Investment in multi-sector research activities, principally the NH&MRC, reached a peak in 2017-18, falling back in 2018-19.

Figure 4: Commonwealth support for SRI - Inflation Adjusted 1978-79 to 2019-20 – Major Categories ($'000)



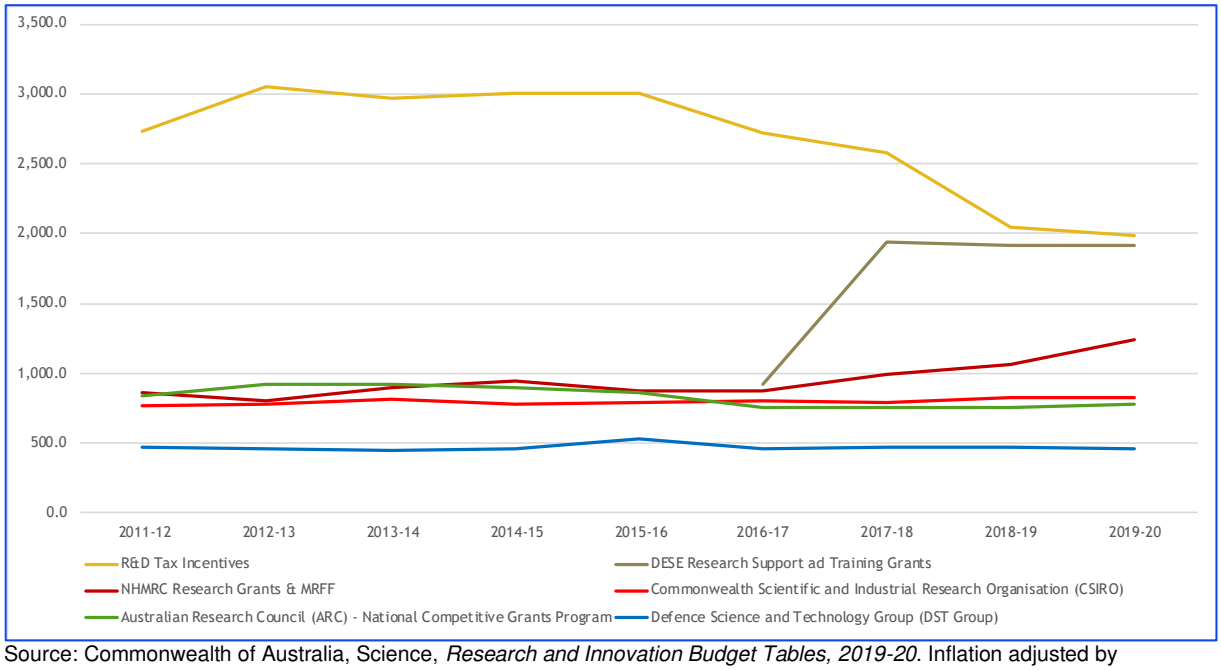
Source: Commonwealth of Australia, Science, *Research and Innovation Budget Tables, 2019-20*. Inflation adjusted by applying the GDP deflator, included in the Table documentation

Expenditure under Commonwealth R&D assistance programs over $400m for the period 20011-12 to 2019-20, is represented in Figure 5. Together these programs are expected to make up 75.9% of total Commonwealth assistance in 2019-20.

Figure 5 points to the continuing significance of the R&D Tax Incentive, which has been declining since 2011-12, and growth in the Higher Education block grants. Except for the ARC, other programs have not changed substantially over the period.

These changes and fluctuations in R&D support over the last 10-year period reflect major discontinuities in Commonwealth research and innovation policy. This is addressed in Section 4 below. But by way of introduction, it is instructive to look at how Australia allocates its research effort.

Figure 5: Commonwealth support for SRI – Major Programs (Inflation Adjusted) 2011-12 to 2019-20



Source: Commonwealth of Australia, Science, *Research and Innovation Budget Tables, 2019-20*. Inflation adjusted by applying the GDP deflator, included in the Table documentation

3.2 Where research investment is being made

In the *2017 Innovation System Report*, the Commonwealth Office of the Chief Economist reported *Government expenditure* on R&D stood at 0.21% of GDP in 2014, having *declined* from 0.27% in 2010, and 0.37% in 1995. This placed Australia *20th* among OECD countries. Perhaps alarmingly, Australia ranks highly in terms of the proportion of Government R&D financed by industry – 9.9% in 2014 (7th) and as high as 13.6% in 2005.

Estimates of Business investment in R&D are currently around one per cent of GDP. This is amongst the lowest in the OECD.

Research expenditure in the *Higher education sector* as a proportion of GDP stood at 0.63% in 2015, having *increased* from 0.58% in 2010, 0.47% in 2005, and 0.39% in 1995. This placed Australia 10th in the OECD rankings.

This increasing investment has been occurring at a time that Commonwealth support for higher education research through ARC national competitive grants has been falling - since a peak of $875m in 2012-13. However, there is now greater support through the research block grants scheme, which potentially gives universities greater flexibility.

Universities are keen to increase their commitment to industrial innovation through collaboration. But, as discussed elsewhere[13] there must be a change in the *culture of the relationship* from one of "research provider", reflected in Government metrics around research

[13] See recent presentation for Australian Innovation Research Group, February 2019

income, to that of "research partner" and "leader" where the returns from co-investment of time, money, and other resources might take many years to materialise.

Universities, as patient investors can, and are, taking lead roles in the development of innovation ecosystems – or clusters, or precincts, or innovation districts.

3.3 What research investment produces – research outputs

The Clarivate InCites (Thompson Reuters) *Web of Science* database indicates that Australia's research output is heavily concentrated in medical and health research.

Over 20 years, Australian medical research output increased from 9,685 Web of Science documents in 1999 to 42,939 in 2019 – a 4.4 fold increase. This concentration of commitment, where the rate of increase is much greater than the world total, is quite remarkable. This is indicated in Figure 6.

Figure 6: Web of Science Documents, Australia trend 1999-2019

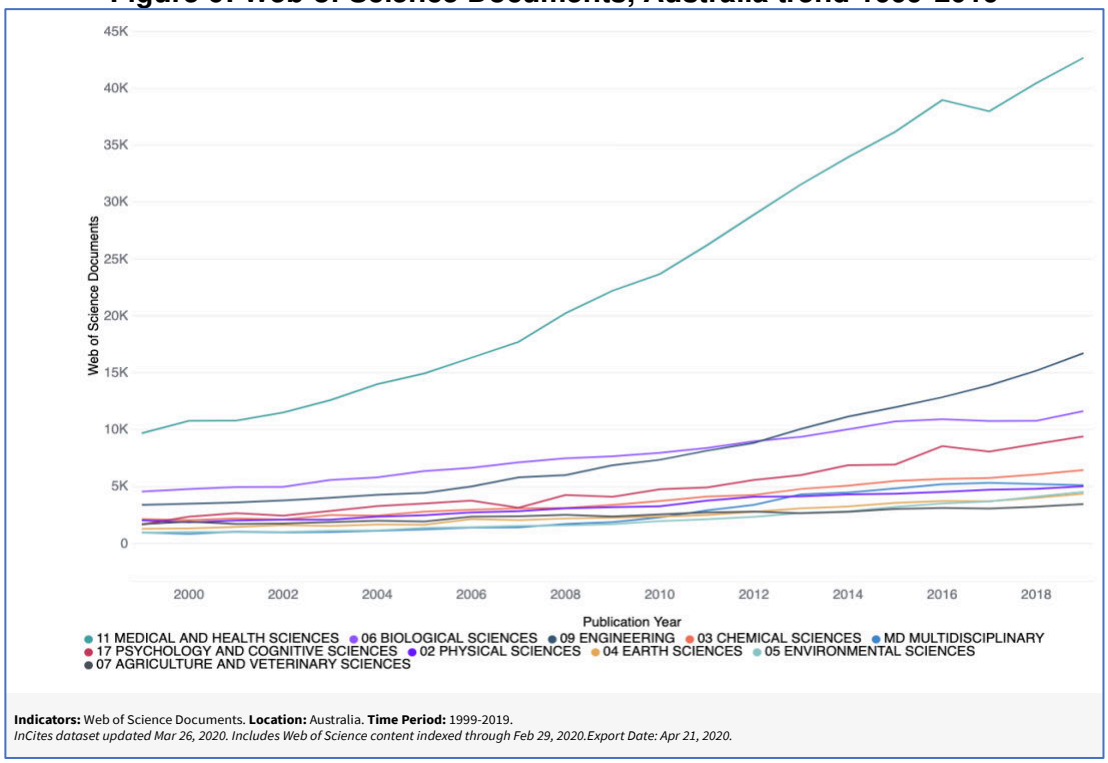
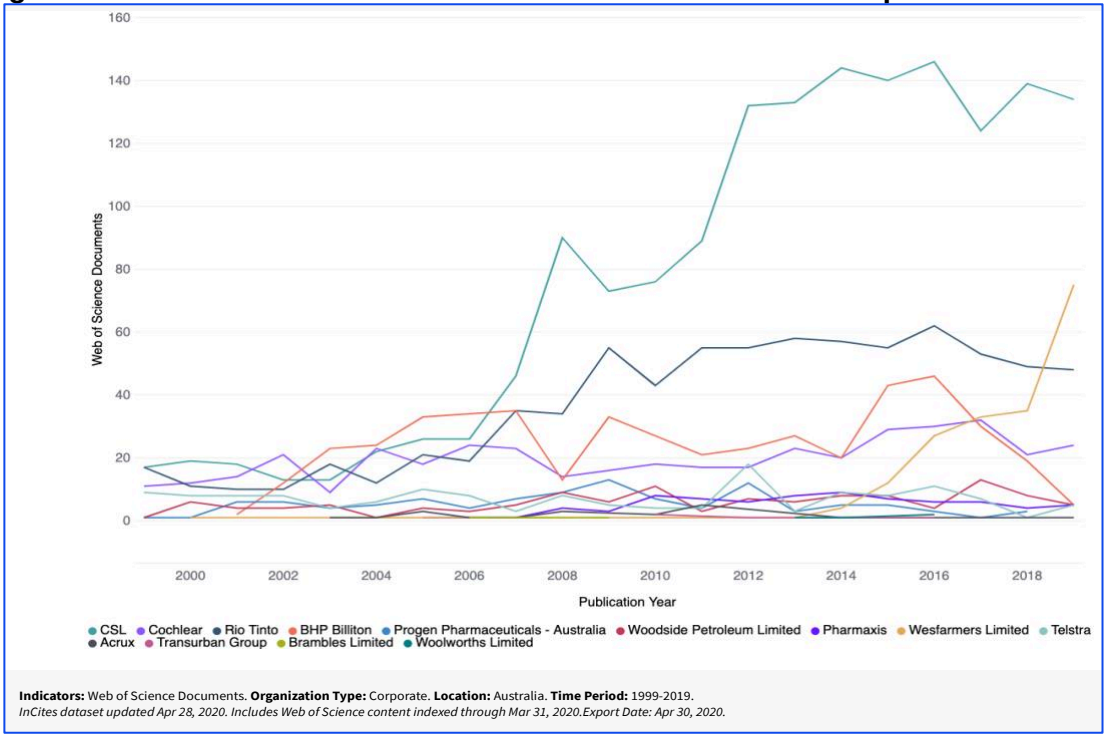


Figure 6 also indicates that research output in Engineering, the second-highest output category, reached 16,776 documents in 2019 (39% of the medical research output). Biological sciences output stood at 11,709, and Psychology at 9,456. Output is dominated by the Go8 universities and medical research institutes. Further information and analysis are contained in Attachment 2.

The Australian *corporate* research output referenced in the *Web of Science* over the period 1999-2018 includes output from a *total of only 13 companies*. This is captured in Figure 7, which covers 2517 documents, many produced in collaboration with universities, CSIRO and medical research institutes.

The output is dominated by CSL, a former Commonwealth Government business enterprise. The other corporations are also known for their research commitment – but the surprise is that there are so few of them. Not included in Figure 7 are the outputs of foreign-owned corporations that operate in Australia.

Figure 7: Web of Science Research Documents - Australian Companies 1999-2019



The profiles are remarkably different in the US which includes just under 200 companies (of which 48 are in California), China (95), Germany (63), Japan (59), France (45), England (35), Sweden (25), Netherlands (18), and Switzerland (17).

The protection regime embodied in Australian industry policy until quite recently would suggest that collaboration between universities and industry has not been part of an Australian industrial research DNA.

Industry-university collaboration only came onto the agenda relatively recently, with the rapid growth of university research, and an observation by policy makers, industry leaders, and public policy academics, that research outputs, and knowledge generated in the process of creating those outputs, could be relevant and useful to industry development – and society in general[14]. There was also a view in the Australian Government during the late 1990s that universities could apply income from their research commercialisation activities to finance their operations.

14 As reflected in the "new production of knowledge" thesis advanced by Michael Gibbons and colleagues - Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies: Sage Publications Ltd. An ARC Report on University-Business Interaction was published in 2000.

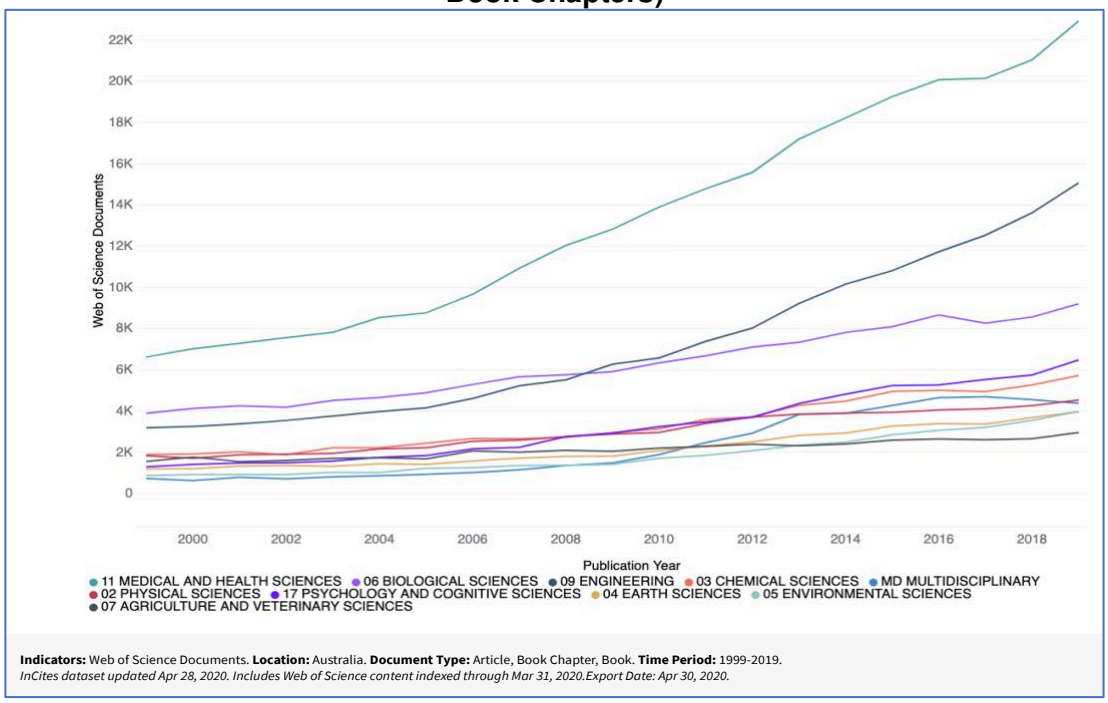
Innovation systems thinking that emerged in the 1990s added to the awareness of the potential for better university-business connections.

But building those connections sustainably has been a slow process, and the institutional relationships between industry and universities are still not as strong as they might be. The challenge is to move from a transactional ethos (buying knowledge, chasing research income) to one that is founded on building long term relationships, mutual understandings of purpose and mission, and trust.

It is an underlying theme of this Paper that there is no natural or inherent tendency for the fundamentally different institutions of universities, business and state (government) to align or converge. This theme is picked up further in Section 5.1 on page 41 below.

The research output trends reported in Figure 6 for all *Web of Science* output are very similar for the more scholarly output of articles, books and book chapters, as indicated in Figure 8. However, although the volume of output is about half of the total, the proportion of output in Engineering is very much higher. This is indicated in Figure 8.

Figure 8: Web of Science Documents, Australia, trend 1999-2019 (Articles, Books, Book Chapters)



The high proportion of non-scholarly research output may suggest that output has a stronger engagement focus with material appearing in other formats such as professional and trade publications, conference presentations, and other forms of media.

Further information on the increases in research output across Fields of Research, is provided in Table 12 in Attachment 2, which shows that output has increased by 200% over the 20 years from 1999 to 2019. In particular:

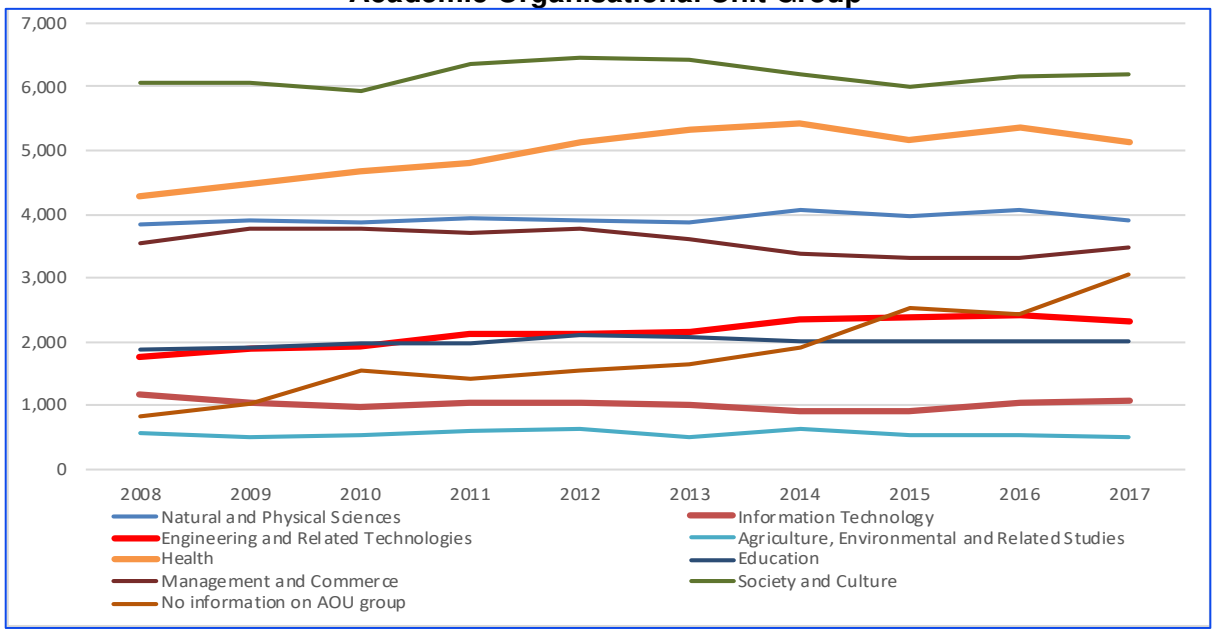
- Research in Medical and health sciences accounted for 20.2% of the increase, and Engineering 14.6%
- Physical sciences accounted for 5.2%, Chemical sciences 5.8%, Biological sciences 7.9%, Information and computing 4.4%, Psychology and cognitive sciences 6.8% and Multidisciplinary research 5.4%.

The relatively low commitment to Information and computing research output is of concern in the digital economy and digital transformation context. However, the increase has been substantial over the period – but off a very small base. The increase has been concentrated in Artificial intelligence and image processing, Information systems, Computation theory and mathematics (analytics), and Distributed computing and software.

3.4 Staffing resources for teaching and research.

Data on numbers of university staff engaged in research (full time or fractionally) are not available. Figure 9 shows numbers of Fulltime Equivalent (FTE) staff working across discipline areas.

Figure 9: FTE Staff with a Teaching only or Teaching and Research function in an Academic Organisational Unit Group



Source: DESE, https://docs.education.gov.au/node/51696

Figure 9 indicates that the highest employing category, Society and Culture, increased from 2010 and fell off in 2013. There is a trend increase in Health and Engineering staff, but a decline in Information Technology. Staff in Management and commerce has been declining since 2012.

3.5 Australia's strong commitment to medical research

Australia's commitment to Medical research is long-standing, well known, and highly regarded within the community. It is strongly supported by governments (Commonwealth and

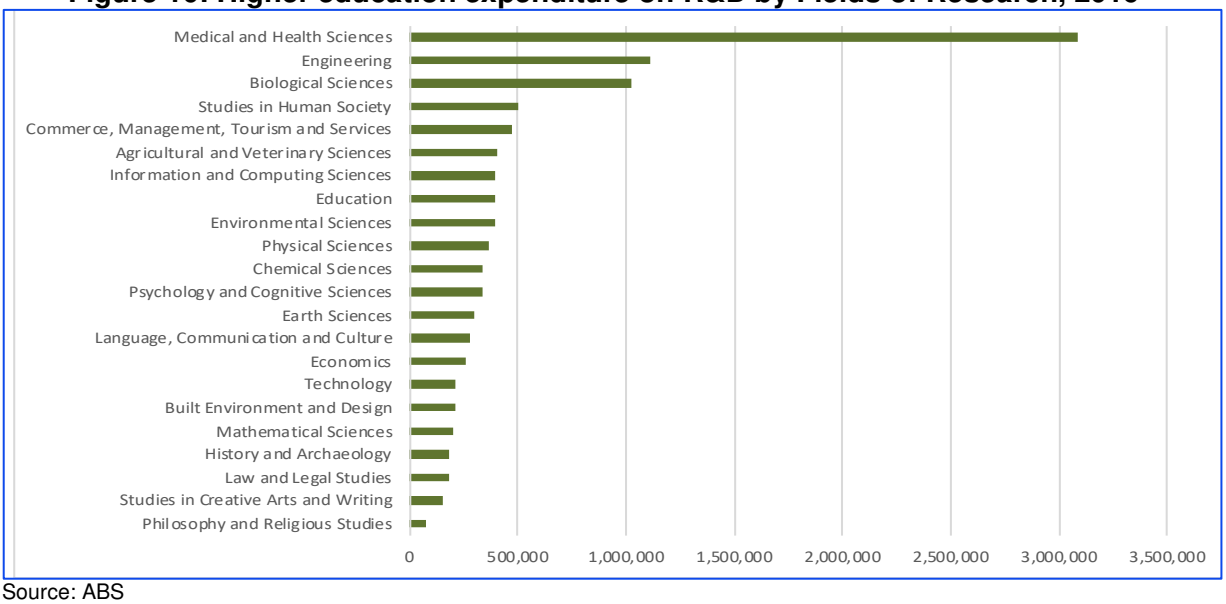
State/Territory)[15], philanthropic donations and bequests, commercial income, and universities themselves. Most of Australia's medical and health sciences research is undertaken in universities and medical research institutes.

A significant amount of medical and health research has been, or will be, translated into application and use (commercialised) in the form of drugs, therapies, and medical devices. A substantial proportion also finds its way into improved, and sometimes breakthrough, clinical procedures and practices. The Australian venture capital and private equity sector emerged in the late 1990s around the opportunities for the commercialisation of medical research. Private sector health care and social assistance currently constitutes about 7.4% of Australian industry value added.

Opportunities for private equity investment in Engineering and Information and computing technologies were fewer, but this is changing, particularly in the last five years or so as opportunities emerge with substantially increased research output in AI, autonomous systems, robotics, data, and analytics.

The emphasis on medical and health services research is further illustrated in Figure 10 which provides information on higher education expenditure on R&D. The chart also points to a significant, but much smaller, commitment to engineering research, and an even smaller commitment to information and computing sciences research.

Figure 10: Higher education expenditure on R&D by Fields of Research, 2016



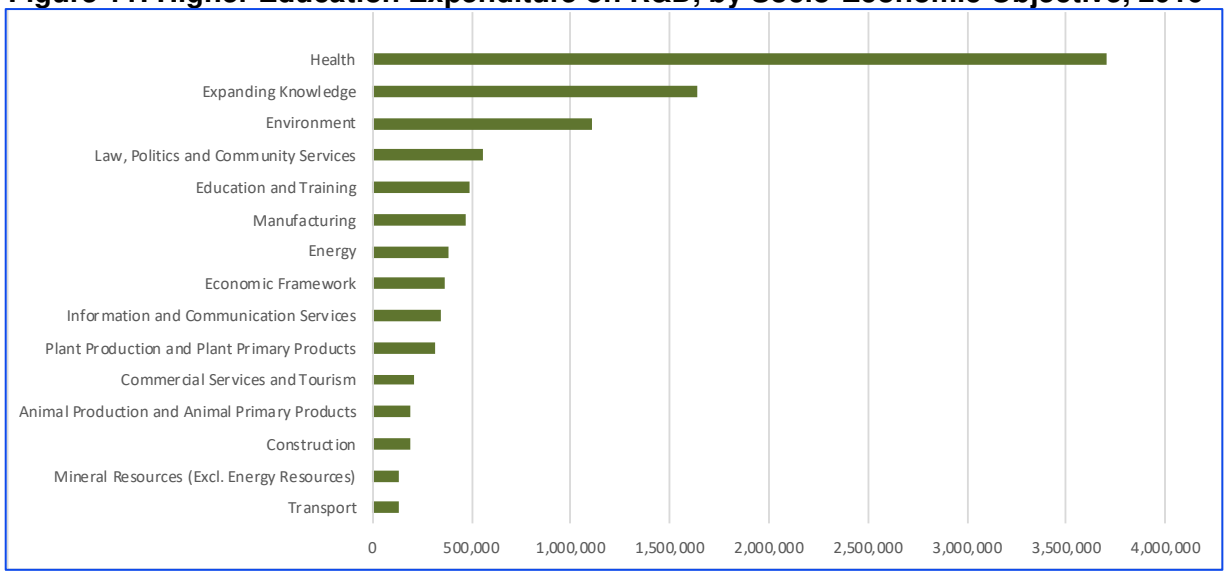
Source: ABS

A similar picture emerges in Figure 11, which presents higher education research expenditure in terms of a socio-economic objective, which provides a proxy for industry focus. The most substantial commitments are to the Health industry, followed by Environment, Law, politics

[15] The National Health and Medical Research Council (NHMRC) was established in 1932. The history of the Australian Research Council is far less stable: The Commonwealth Universities Grants Committee was established in 1946, followed by the Australian Research Grants Committee in 1965, and the Australian Research Council in 1988 – as one of four Boards under the National Board of Employment, Education and Training. NBEET was abolished 1n 1996, but the ARC continued. In 2001 the ARC was incorporated as a statutory body.

and community services, Education and training, and then Manufacturing and Energy. The amounts invested in Construction and Transport are very low in comparison.

Figure 11: Higher Education Expenditure on R&D, by Socio-Economic Objective, 2016



Source: ABS

The high level of research into medical and health sciences by universities may be, at least partially, explained because this is where the money is.

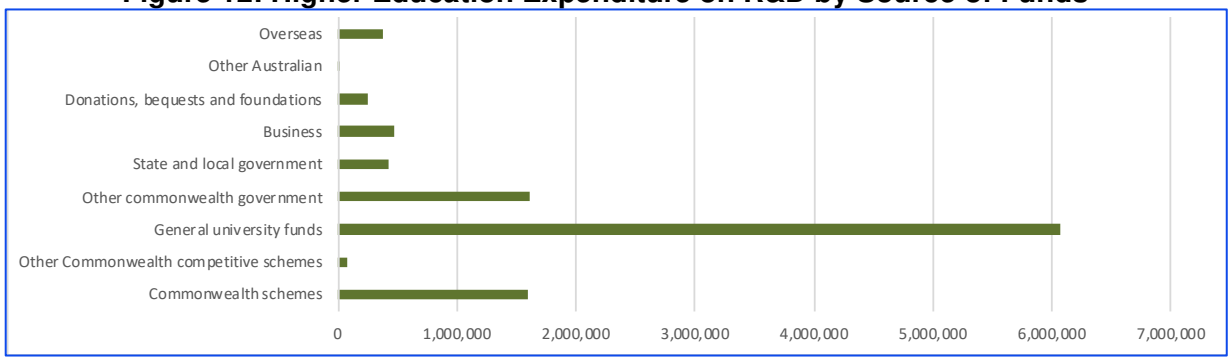
Government commitment to medical research is strong through a variety of channels, as is philanthropy – reflected in the formation of numerous Medical Research Institutes that connect with university Medical faculties. Global pharmaceutical and medical device companies (including CSL and Cochlear) form research partnerships with universities – although the direct funding of research projects raises serious ethical concerns.

Moreover, as medical research also attracts high citation and indexing in prestigious journals, feeding into global university rankings, universities may be motivated to allocate a higher proportion of internal resources to the Field. Anecdotal evidence suggests that a significant proportion of internal funds finds its way to medical research.

Figure 12 shows the sources of funds for Higher Education Expenditure on R&D for 2016. By far, the largest proportion comes from general university funds[16].

[16] The high proportion of General university funds in the financing mix reflects the 'peculiarity' of the Australian research system in its reliance on student fee income, both domestically and internationally. This is possibly precarious as other counties build their university systems, as well as potentially diverting fee income from teaching and enhancing the student experience.

Figure 12: Higher Education Expenditure on R&D by Source of Funds



Source: ABS

There is possibly much to be learned for other Research Fields and industry about the way that Medical and health sciences research and industry partnerships have grown in the Australian context.

The Medical research story involves stability, certainty in institutional arrangements, long term commitment, and the building of trust between the institutions and organisations involved. It has also involved a long-term focus rather than looking for quick transactional returns from motivations such as "more money for research", formation of "start-ups" and premature "commercialisation" – although blockbusters do happen[17].

Australia's investment in medical research, particularly in fields such as immunology, has been a major factor in Australia being able to take a global leadership role in addressing the COVID-19 virus.

It does not follow that the concentration of research in the Medical and health sciences field means that resources should be reallocated way from this area. Rather, it suggests, together with Australia's very poor level of commitment to R&D, that much more should be invested in other areas, mainly by higher education in fields associated with "new industries" including Engineering and Technology and Information and Computing Sciences.

Lifting higher education research in Engineering and Technology, and Information and Computing Sciences would complement business investment in these fields.

This is addressed further below, including specific funding arrangements to build capacity and capability.

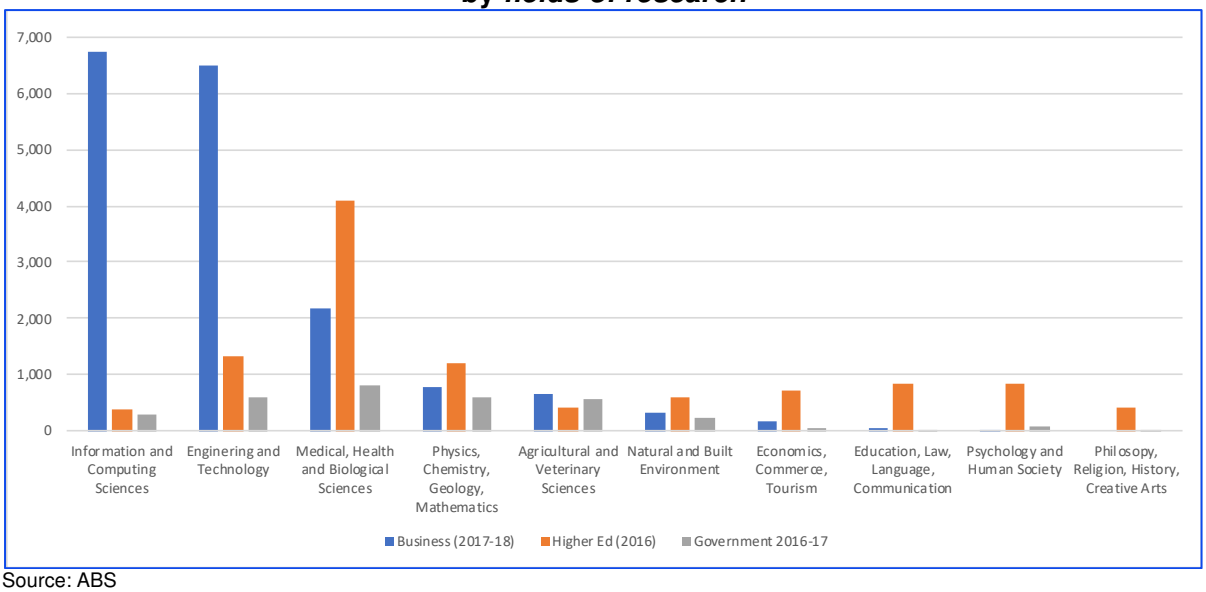
[17] The Bio21 Project in Parkville, Melbourne commenced on a tenuous basis 20 years ago and has developed into a robust, globally focused capability.

3.6 A business-higher education-government research investment mismatch

The most recent ABS data indicates that Research and Development Expenditure by Business, Higher Education, and Government totalled $31.6 billion. Of this total, Business accounted for $17.4 billion (55.2%,) Higher Education $10.9 billion (34.4%) and Government $3.3 billion (10.4%).

Of this total, 81.9% was concentrated in four broad areas: Information and Computing (23.5%), Engineering and Technology (26.7%), Medical and Health Sciences (22.5%, and the STEM fields of Physics, Chemistry, Geology and Mathematics (8.1%). However, the distribution of this research *between* sectors shows a remarkable divergence. This is reflected in Figure 13.

Figure 13: Business, Higher Education and Government R&D Expenditure categorised by *fields of research*



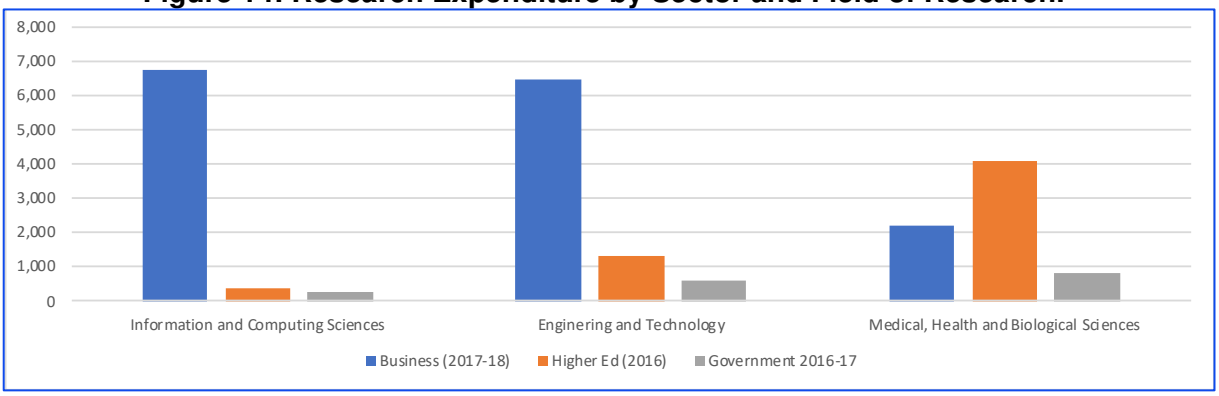
Source: ABS

Figure 13 indicates that business undertakes the greater part of research and development in Information and computing and engineering and technology (90.8% and 77.1% respectively) whilst Higher Education research is heavily concentrated in medical, health, and biological sciences (57.8% of total Higher Education expenditure). State Governments allocate 35.1% of expenditure to agricultural and veterinary sciences[18].

This mismatch between research effort is illustrated more starkly in Figure 14.

[18] Much of this research is financed from rural research and development levies, matched by the Commonwealth, and managed and allocated by the Rural Research and Development Corporations.

Figure 14: Research Expenditure by Sector and Field of Research.



Source: ABS

In general terms, Business expenditure on R&D amounts to 84.2% in STEM type disciplines (excluding medical, health and biological sciences), whereas Higher education allocates 30.7% to STEM, 37.8% to medical, health and biological sciences, and a further 31.6% to the natural and built environment and HASS type disciplines.

The "mismatch" between research expenditure between business and higher education may imply that higher education research has limited complementarity with business research priorities

Our analysis of the Higher Education sector commitment suggests differences in expenditure commitment may reflect a significant divergence in funding sources and historical commitment, with implications for the scope and opportunities for collaboration, and the mix of research outputs. Of particular concern is the potential underinvestment in the Industries of the Future.

3.7 Investment in Industries of the Future

Commitment to medical research has a long history in Australia, largely motivated by purposes relating to improvement in the human condition. It has underpinned a flourishing health services sector that contributes 7.6% to GDP. But the much lower commitment to research in engineering, technology, and information systems suggests we are overlooking a priority to invest in the industries of the future.

According to Eric Ross in T*he Industries of the Future* (Simon & Shuster, 2016), these industries encompass: robotics and artificial intelligence; advanced life sciences; the "codification of money"; cybersecurity; and big data. To these a number of others could be added, including visualisation, autonomous transport, nanomaterials, energy capture storage and transmission, and what is sometimes referred to as "the Internet of Things".

The growth of new industries are being powered by the global technology companies that design and produce the technology-intensive hardware (steeped with microprocessors and sensors) and embed the code and programs (software) that provides the foundation for business systems, AI systems, consumer durables, cameras and video equipment, and keep businesses and people connected. They are some of the most profitable businesses in the world.

The new industries fuel the growth, disruption, and transformation of other industries and help build their asset bases and profitability.

This is particularly noticeable in financial services: the banking, insurance, diversified financials, and business supplies and services industries currently make up one-third of the asset value of the *Forbes* Global 200 (total assets amount to $US137 trillion, representing 74% of total assets). Their profits amounted to $US14.5 trillion (25.5% of the total).

These industries of the future will, of course, also have profound impacts on the human condition, including the use of data to improve human health on a broader scale and in a broader context of wellbeing in individual, economic and socio-cultural contexts. These may be brought about by changing education and skill requirements and adjustments to a digital environment.

But the disparity between the commitment to medical research compared with the commitment to research in engineering that will drive the evolution and maturity of new industries is a matter of some concern. While Australia is a world leader in medical research, it is very much a laggard in engineering research. Of course, Australia maintains an enviable reputation for ingenuity in engineering, forced upon it by the tyranny of distance, and the challenges of its environment.

The new industries call on many research fields in engineering, as well as in technology, information and computing, and mathematics. Recent data indicates that universities invest $4b in the life sciences research (medical, health, biology). By contrast, investments in research relating to the new industries are very small.

These new industries are also where innovation is proceeding, where the jobs are, and where the jobs of the future are likely to be. They transcend the impact of the potential for innovation in the “classical” industries defined by Standardised Industrial Classifications (e.g. ANZSIC). They include the industries that must be transformed to secure Australia’s future in terms of productivity growth and transition to meet the 2050 net-zero emissions target. These include: Manufacturing, Transport, Electricity production, Construction (mainly residential and commercial building), and Agriculture.

This apparent priority difference between medical research and new industries research centred on engineering reflects conscious policy priorities by governments, and in universities, on how to allocate funds for research investment. There is an abundance of money for investment in medical research, and universities allocate a substantial proportion of internal funds to that purpose as well.

For quite some time Australia has massively underinvested in research relating to the new industries, particularly compared with China and other “BRIC” type nations.

4 Policy gaps, failures, and missed opportunities

A view has emerged among innovation policy analysts and commentators that the Australian Government has lost its way, or even interest, in the development of an effective national innovation and industry strategy, including fostering engagement between industry and research organisations. Responsibilities, accountabilities and funding arrangements are distributed across multiple portfolios and a plethora of "funding programs", or "buckets of money".

The effect has been that national innovation and industrial strategy has become an amalgam of regular *announcements of funding programs*, with scope determined by cross-portfolio trade-offs, with short time horizons, generally small amounts of project money[19], and every possibility that they will be discontinued after the next change of Minister, Federal election, and/or in the next round of fiscal austerity and search for budget balance.

4.1 Funding programs – fostering initiative or allocating "free money"

Funding programs are not always driven by strategy. They are driven by Ministers wanting to be seen as "doing good", and the perceived attractiveness to business of getting money for minimal effort. Ministers enjoy making announcements about the availability of a fixed amount of money to be available as financial support or assistance for "eligible" projects or programs. An application process is then set in train. It is well acknowledged that the best applications more often succeed, rather than the best projects.

Ministers' intentions are generally to support the effort and commitment of businesses in areas that accord with the government's understanding of potential contribution of an applicant enterprise to national industry development and innovation goals. Professional grant writers can help wordsmith this contribution. This is analogous to social programs that were initiated to support NGO's "charitable efforts"[20]. Health and social assistance programs now reflect a *contract for service* arrangement.

The funding program model is wide open to the influence of professional lobbying - and potentially corruption.

Access to "funding" money is determined by the extent to which applications meet the grant criteria. Criteria tend to emphasise process rather than outcome. Applications are assessed and ranked by Departments and Advisers using a variety of scoring or rating systems. Procurement requirements limit the amount of contact grants officers can have with applicants. Questions and answers are generally shared among all potential applicants. This seriously reduces the potential for project innovation[21].

Funding programs rarely reflect a mission and a clear statement of outcome or results – that is, what will be achieved and measured. It is more about what will be spent and less about the impact on growth, performance, and productivity. It is a tactical and transactional approach

[19] Inevitably to be spread "equitably" across States and Territories and electorates.
[20] As the funds provided social programs increased, they became increasingly rules based and transformed into "outsourcing" programs for the delivery of a range of specific services.
[21] But as we have discovered recently, Ministers can override Departmental recommendations to meet overt political ends. This is not, of course, a new phenomenon.

that supports activity, rather than an investment plan that will support sustained growth. The approach is often based on a "hope" that money will deliver beneficial outcomes for the industry and the economy.

An important KPI for funding programs is often to ensure that all available funds are spent within a given time period.

Rarely is there any audited trail or follow-up with grantees about the extent to which funds have been effective in achieving stated results. There is no mechanism to assess whether a CRC, for example, has achieved what it set out to do after the CRC is would up. Non-audited results, such as economic impact calculations that generate big numbers, can be highly deceptive – and often fail the logic test in terms of claimed contribution to GDP.

Recent experience has demonstrated that while the Commonwealth has a skill in making announcements about funding to address a particular problem or opportunity, it is far less skilled in implementation. Commonwealth public servants tend to be "policy people" and far less versed in the intricacies of program delivery and implementation. This was amply demonstrated in the Home Insulation Program and in a litany of Auditor-General's Reports that highlight poor program administration.

Possibly reflecting a US trend, national policy outcomes are determined less by evidence and more by the relative strength of lobbying efforts (and resourcing). This contrasts with a "partnership" between government-industry-universities (as in the "triple helix" concept) to achieve beneficial national results. In this paradigm though, the innovation lobby is not strong[22].

In a context of declining public support for science, research and innovation, and absence of an overarching innovation/industry strategy, there is continuing interest among policy-makers and academics with innovation system performance and metrics, and making the best out of poor performance in areas such as government and business expenditure on R&D[23]. The RBA and the Productivity Commission, however, are raising serious concerns about our productivity performance.

The attention given to analysis, measurement, and description by policy-makers perhaps reflects an endeavour to demonstrate that the Australian innovation picture might not be as bad as international comparisons might show. So far, metrics frameworks have not been able to come up with any long-term strategies to lift productivity, government and business investment, and collaboration in research.[24]

22 The university sector is already moving to narrative along the lines "we want to be Partners, and this is how we can help". This is increasingly being played out in the States/Territories.
23 See the recent ISA sponsored paper Australian business investment in Innovation" : levels, trends, and drivers. https://www.industry.gov.au/sites/default/files/2020-02/stimulating-business-investment-in-innovation.pdf
24 The Department of Industry Innovation and Science recent Discussion Paper, "Improving Innovation Indicators" addresses issues concerned with interpreting and developing collaboration metrics but does not offer solutions.

A stage has been reached where public support for innovation and industry development has evolved into a short term funding dramaturgy where governments look for political kudos, and a large number of consultants and advisers provide a commercial service to businesses to access the disconcertingly large volume of available grants to provide what is essentially "free money"[25].

4.2 Sector-based or technology-based approaches

It might be argued that a "sector" approach to innovation and industrial strategy is emerging in separate policy domains under the responsibility of different Ministers and Portfolios – Agriculture, Defence, Health, Infrastructure, Mining, Energy, Transport, Treasury (Financial Services), for example[26]. Some portfolios have a more substantial commitment than others. The sector approach is embedded in the Industry Growth Centres initiative, and it may be the best we can do at the current time.

A sector approach might not, however, sufficiently address strategies for critical *enabling* innovation technologies and capabilities at scale that cut across sectors – such as Information systems and computing, engineering, and the creative industries. Information Systems and computing policy has fallen between sector "cracks" in Ministerial Portfolio responsibilities ever since the Goldsworthy Report of 1997 (Australia. Information Industries Taskforce, 1997). It has been a major area of policy failure, but it must be addressed from a cross-sector perspective.

ICT and Digital Transformation is now front and centre of industry strategy and innovation policy initiatives across the world.

Even now, ICT policy sits uneasily in the Department of Industry, Science, Energy and Resources and CSIRO's Data61. Still, connections with ICT intensive industry portfolios such as Agriculture, Defence, Education, Health, Transport, and Treasury are not clear. Recent policy initiatives have been launched from the Department of Prime Minister and Cabinet.

It might be argued that it is just too hard, and the Commonwealth should vacate the space, leaving innovation strategy responsibilities with the States/Territories and universities working closely with the business sector to address State and regional priorities – which of course differ among States. After all, universities are *State*-owned public organisations.

State governments have many of the policy levers to encourage universities in their States to collaborate, build scale and critical mass in areas of research, teaching, and engagement. For

25 During the consultations for the ISA 2030 Strategy successful companies indicated their irritation by unsolicited approaches by consultants to find them a grant – for a fee. These companies indicated they would prefer to generate income from customers rather than taxpayers.
26 As indicated to some extent with the Growth Centres Program.

example, NSW Departments of Agriculture, Health, and Education have partnership and collaboration arrangements with all universities in NSW.

Collaboration in Quantum Computing

The NSW Government and NSW universities are collaborating in the establishment of a Sydney Quantum Academy (SQA) to be jointly developed with the University of Sydney, UNSW, UTS and Macquarie University.[27] The Academy, which will receive $15.4m from the NSW Government, aims to:

- Encourage students to collaborate and train across the four universities
- Directly link students to industry through internships and research
- Support the development of quantum technology startup businesses
- Promote Sydney as a global leader in quantum.

Victorian and Queensland Governments have also been active in investing in building research capacity and capability for at least 20 years. Some examples are provided in Attachment 1.

4.3 Regional development and place-based innovation

National and one size-fits-all approaches to industrial strategy and innovation policy do not work for Australia's diverse climatic, resource, and federal structure. It makes little sense to talk of a National Innovation System: Australia is an aggregation of six state-based innovation systems – many of which are significantly larger than the often-celebrated Nordic innovation systems and nation-states such as Israel and Singapore.

Each State/Territory has developed and implemented industrial strategies and innovation policies going back many years. Victoria made a strong commitment to innovation 20 years ago with its STI initiative, and a short time later, Queensland under the Beattie Government initiated the Smart State Strategy. The theme continues with the *Advance Queensland* Strategy. In 2008 the ACT Government supported its Canberra Regional Innovation Network initiative. Other States followed more slowly, with NSW being a laggard and only recently making a strong commitment to a Research and Innovation Strategy.

Most State/Territory Strategies set out to leverage University, CSIRO, and Medical Research Institutes (MRI) commitments to Research and Innovation and Commonwealth initiatives such as Defence and Aerospace. They also seek to leverage Commonwealth Programs, such as the CRC Program and the Export Markets Development Grants Program. Most have minimal funding and grants initiatives in their priority areas.

Within these State based-systems are multiple sub-regional systems with a concentration of innovation activity in the large conurbations: Sydney-Newcastle-Wollongong; Melbourne-Geelong; Brisbane-Gold Coast- Sunshine Coast; Adelaide; Perth; Tasmania; and Canberra-Capital Region. There are small pockets of innovative activity in rural areas with a university, but the scale is small and connections and collaborations with similar areas weak.

Regional development policy and strategy has been a particular problem for the Commonwealth Government. State Governments argue that regional development is their responsibility. They control most of the policy levers – such as land-use planning, development

[27] See https://www.finance.nsw.gov.au/about-us/media-releases/sydney-quantum-academy-create-jobs-future

controls, infrastructure investment, and local government itself. Commonwealth grants and financial assistance is sought and encouraged – as long as it fits within State priorities.

With the growing importance of placed based innovation, around regions, precincts, districts, and hubs, the Commonwealth is constrained in its capacity to develop and implement industrial strategy and innovation policies in this important domain. Currently, it has recourse to the very small grant driven Innovation Precincts Program and is able to leverage the City Deals Program. Grants have also been made to "depressed regions" such as Geelong after the GMH closure, Newcastle after the BHP closure, South Australia, and Tasmania.

Grants and loadings are also attached to other programs, such as universities funding. But these are not necessarily driven by innovation outcomes. The Regional Development Australia initiative is essentially a lobbying arrangement for communities and for applying for grants from discretionary Commonwealth funding programs, including Building Better Regions Fund.

The absence of a clear and consistent Commonwealth regional policy that addresses place-based innovation is a serious policy gap.

4.4 Innovation system governance, partnership, and trust

The underlying problem is that the Australian approach to industrial strategy and innovation policy is that it has never addressed the governance, management, and organisational aspects of innovation systems and performance.

With a focus on funding programs and short-term commitment (rarely more than three years), there is little room to seriously address longer-term missions or achieving strategic goals. This is in contrast to a true managerial approach where *mission and strategy come* first, which, in turn, provides the basis for consideration of the investments required. It is only with an agreed plan that consideration of how investments will be made, and who will make them, makes sense. Investments may be financed through commitments between public, private and university sectors.

Of course, investors may baulk at investing in desired projects on the grounds of cost, risk, and return. These disciplines are sometimes applied in public policy contexts, but the discipline should be applied more widely. Behaviours may change if granting agencies see themselves as *investors* rather than custodians of buckets of money. It is an approach that is adopted widely in the Rural Research and Development Corporations.

This is in contrast to the US where management was, and is, regarded as the "visible hand" in industrial innovation, and the managerial revolution is celebrated (Chandler, 1993, Chandler, 1994) and the profession of management is highly regarded (Drucker, 1993, Drucker, 1994). There have only been a few Australian contributions in this context, though interest may be increasing (Green et al., 2009, Green, 2013, Karpin, 1995, Carnegie et al., 1993, Samson, 2010, Dodgson et al., 2008, Dodgson et al., 2015).

The management of innovation systems at the national level is a daunting and perhaps an impossible task. It explains why attention is

shifting to the management of regional, or place-based, innovation systems.

Committees, Councils, and Advisory Groups have been established with great intention and fanfare, but inevitably have been allowed to wither on the vine as they challenge Departmental authority and control, and rigid portfolio silos. The latest example is Innovation and Science Australia (ISA). The complex processes for preparing the 2030 Innovation Strategic Plan provide some insights into the reasons for its failure to provide leadership in industrial strategy and innovation policy. ISA has been largely sidelined in these areas. It is now producing "safe" information papers.

In an ideal world, the availability of public funds to support a business or industry should be based on partnership and trust developed over a longer-term lead time with transparent processes, agreed outcomes, accountabilities, and reporting arrangements. But often there is indecent haste in trying to get money out the door. Trust was absent in the motor vehicle subsidy programs where US global automakers played the Australian Government on deceptive promises and false hope.

The Industry Growth Centres Program, launched in 2013, had great potential to lead as "hubs" or "beacons" for strategically driven innovation and industry policy and investment. But the amounts involved are small, the commitments short term, and engagement with the many other policy entities and advocates are often weak. Industry Growth Centres now have a role in advising the ARC on applications under various programs such as the Industrial Transformation Research Program. They are also encouraged to provide advice to research applicants with guidance prior to submission.

5 Policy imperatives

5.1 Achieving a closer match between industry and university research priorities

Achieving a closer match between industry and university research priorities is much more complicated than matching Fields of Research and reallocating funds. It is one that may take time and involve the development of mutual understanding of priorities, partnerships, and investment priorities.

Central to the issue is the organisational and interpersonal relationships, the social capital, that must develop across sectors. Developing these relationships takes energy, commitment, and resources.

As there is such a high level of external funding available for medical research, with long-term commitment and stability, this is where the priorities of universities seem to be. In other areas, the potential to develop stronger relationships has been weakened by discontinuities in innovation and industry policy. These funding arrangements are short term, and with levels of program/project assistance often too small to make a real difference.

Achieving a better match between university, business, and government RDI commitment must address the competing missions and priorities of these three "institutional pillars". The characteristics of each pillar and their principal drivers are set out in Table 4 below.

Table 4: Business, Universities, Government: Different Characteristics and Drivers

Institutional pillar	Businesses	Universities	Governments
Mission	To create and retain customers	Creating, expanding, and disseminating knowledge	Economic growth, employment, price stability, equity and social inclusion
How	Delivering goods and services that satisfy wants in a better way than competitors	Education, research, business/ community engagement	Efficient and effective policies and programs
Activity Orientation	Production and markets – sales, customers. Suppliers.	Independence, autonomy, process, procedure	Rules, regulations, hierarchy, compliance (bureaucracy)
Accountability	Boards, Shareholders, Bankers, Regulators, Community (SOL).	Governing Councils. Granting Agencies. Regulators.	Parliament, Voters, Scrutiny Agencies
KPIs	Sales, market share, share price	EFSL, Research income, global rankings	Voter sentiment, popularity
How success is viewed	Brand, reputation, loyalty, trust	Eminence, int. reputation, student experience	Leadership, integrity, trust
Viability test	Financial benchmarks. ROI	Financial benchmarks. Community confidence.	Balanced budgets. Elections
Appetite for risk	High (i.e. the nature of entrepreneurship)	Very Low	Moderate to low; scrutiny by large no. of "integrity" bodies, media

There is no inherent or natural tendency for the fundamental missions and purposes of each pillar to converge. However, it has proved to be easier to forge these connections in more cohesive geographical regions and localities where institutional settings may not be as entrenched and social capital is better developed. This may explain the increasing attention to urban and regional innovation ecosystems (clusters, precincts, districts) with their potential

for greater flexibility and agility, rather than the more abstract level of national systems and programs.

To achieve optimal outcomes, whether at the national or local level, closer collaboration requires "institutions for engagement" that enable people and organisations to work towards the development of deep-seated trust-based interactions.

Whether such institutions are provided by government or evolve spontaneously, it means moving from a transactional view of relationships (including "merchandising knowledge products") to one of partnership, mutual commitment, and respect.

5.2 Sustained RDI investment in key industry sectors

In terms of the accepted Socio-economic (SEO) categories used widely in RDI publications, committed and sustained RDI investment is required in most groupings to achieve the transition to new sources of growth. The track record of sustained investment over the last 30 years, and even the last 10 years, has not been good.

5.2.1 Science Research and Innovation (SRI) investment trends

Drawing on the comprehensive dataset contained in the 2019 DISER, *Science, Research and Innovation (SRI) Budget Tables,* Commonwealth R&D investments over the past 30 years, classified by major socio-economic category (SEO) are shown in Table 5.

Table 5: Australian Expenditure on SRI 1998-89 to 2019-20 by SEO (5 yearly intervals) - Inflation Adjusted

Socio-Economic Objective	1989-90	1994-95	1999-00	2004-05	2009-10	2014-15	2019-20	Investment 1990-91 to 2019-20	Average Investment Per Annum	Proportion of investment
00. Multiple categories	1,513	2,324	1,848	2,948	4,113	5,207	4,120	99,454	3,315	43.0%
01. Exploration/exploitation of the Earth	133	131	152	150	340	126	124	4,748	158	2.1%
02. Environment	26	29	40	56	73	46	50	1,587	53	0.7%
03. Space	10	22	6	6	68	45	41	653	22	0.3%
04. Transport, comms, infrastructure	4	4	52	38	7	13	2	519	17	0.2%
05. Energy	22	20	5	7	298	425	224	3,473	116	1.5%
06. Industrial production	215	455	644	735	919	372	227	16,414	547	7.1%
07. Health	206	276	302	552	938	1,031	1,342	21,026	701	9.1%
08. Agriculture	152	227	223	366	375	415	455	9,788	326	4.2%
09. Education	-	0	0	0	0	0	0	3	0	0.0%
10. Culture, recreation, mass media	-	0	0	0	0	0	0	0	0	0.0%
11. Political and social systems	-	0	0	5	100	113	46	1,654	55	0.7%
12. Advancement of knowledge	1,737	2,514	3,010	1,951	1,831	2,076	2,068	67,533	2,251	29.2%
14. Defence	463	448	397	443	485	471	453	13,731	458	5.9%
Total Inflation Adjusted	4,482	6,451	6,679	7,258	9,550	10,342	0	231,436	7,715	100.0%
Total Nominal	*2,274*	*3,562*	*3,996*	*5,162*	*8,318*	*9,835*	*9,636*	*190,795*	*6,360*	

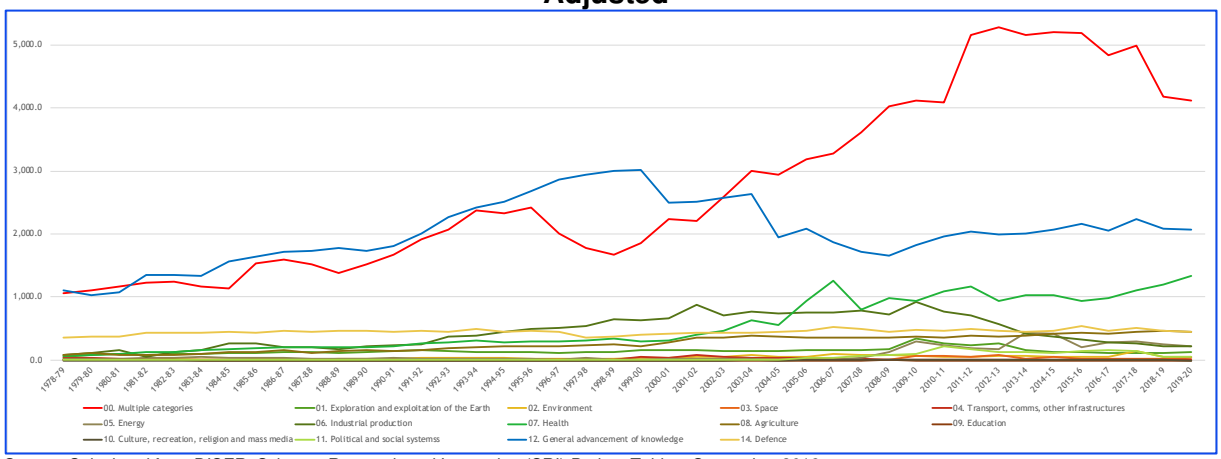
Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

Table 5 indicates that there has been, and continues to be, a high priority given to generalised *Multiple* Research and Development Categories. These include CSIRO, the ARC, and ANSTO. Other areas that reflect high research expenditure priorities are Industrial Production, Health, Defence, and to a lesser extent, Agriculture.

Of concern, however, is the implicit low priority given to research in Exploration and exploitation of the Earth (land and water research), Transport, communications and other infrastructures, and Education. These are areas where major research commitments are required as a foundation for transforming the economy to new sources of growth.

Trends in SRI expenditure classified by SEO categories over the 30 years from 1989-90 to 2019-20 are shown in Figure 15 below.

Figure 15: Australian Expenditure on SRI 1978-79 to 2019-20 by SEO - Inflation Adjusted



Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

The research expenditures included within the generalised Multiple R&D category are listed in Table 6.

Table 6: Australian Expenditure on SRI – Multiple Category, 2015-16 to 2019-20

Program / Activity	2015-16	2016-17	2017-18	2018-19	2019-20
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	750.3	787.3	793.5	834.6	839.2
Australian Research Council (ARC) - National Competitive Grants Program	815.3	743.7	758.0	764.1	791.3
Australian Nuclear Science & Technology Organisation (ANSTO)	192.6	212.2	219.2	242.5	257.8
Geoscience Australia	121.3	142.6	151.1	184.4	192.3
National Collaborative Research Infrastructure Strategy	150.0	150.0	421.3	160.8	181.9
Australian Institute of Marine Science (AIMS)	40.5	41.6	44.8	47.4	44.8
Bureau of Meteorology Research Activities	24.3	17.3	15.2	16.3	16.6
Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS)	0.8	3.0	1.4	1.4	1.8
R&D Refundable Tax Offset	-25.0	-25.0	-	-	-
R&D Tax Incentives - Refundable	2,064.0	1,967.0	1,929.0	1,699.0	1,732.0
R&D Tax Incentives - Non-Refundable	780.0	700.0	650.0	360.0	280.0
Total	**4,914.1**	**4,739.6**	**4,983.5**	**4,310.5**	**4,337.7**
Inflation Adjusted	***5,194.6***	***4,828.9***	***4,984.8***	***4,175.8***	***4,119.8***

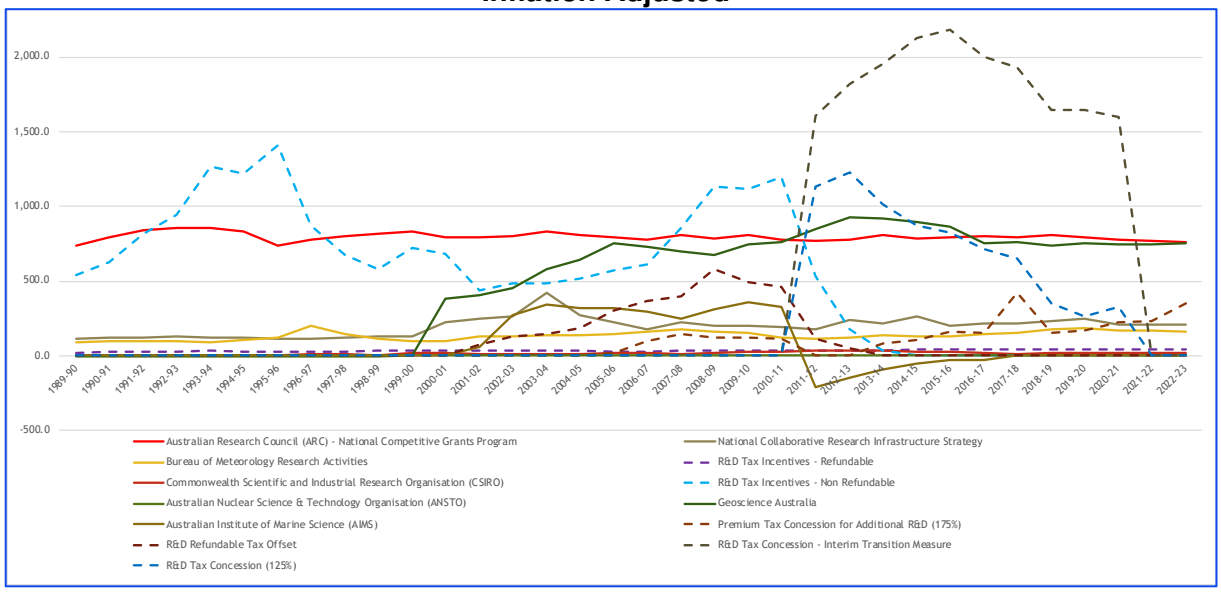
Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

The R&D Tax Incentive (RDTI) is the largest component of the Multiple R&D SEO category, although it has fallen substantially over the last five tears.

The reduction in support for the RDTI has not been offset by reinvestment in other SEO areas.

Over 30 years the RDTI has had a turbulent history, with multiple program and eligibility changes as the Commonwealth tries to reduce its Budget exposure. This is clearly indicated in Figure 16 below, which charts all expenditure items in the Multiple objectives category. The negative trend for AIMS reflects the impact of incorporation within CSIRO.

Figure 16: Australian Expenditure on SRI 1978-79 to 2019-20 - Multiple Objectives - Inflation Adjusted



Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

5.2.2 Addressing the dissipation of SRI support

Concern over the dissipation of R&D support, in terms of the number of R&D programs, was raised in the UTS report for the Senate Innovation System Inquiry, *Australia's Innovation Future* (Green and Howard, 2015b).

The DISER R&D Budget dataset currently shows a very large number of R&D grants spread across all SEO categories. Over the 30 years to 2019-20 there have been 483 separate programs of expenditure – some with an average duration of 24.4 years and others with an average duration of three. Many of these have been quite small. The complete list of programs is provided in Attachment 5.

The DISER R&D Budget dataset shows that in 2019-20 there are 139 SRI support programs. This is 50 (26%) less than the peak of 189 reached in 2012-13.

A summary of the number of SRI programs, average years duration, and average program expenditure is provided in Table 7.

Table 7: Australian Expenditure on RDI 1978-79 to 2019-20 - Number of Programs Funded

SEO	No of Programs 1978-79 to 2019-20	Average Duration (Years)	Average Annual Program Expenditure
00. Multiple categories	14	24.4	353.2
01. Exploration and exploitation of the Earth	17	7.6	17.8
02. Environment	30	7.9	5.5
03. Space	7	11.1	11.2
04. Transport, comms, other infrastructures	24	6.2	2.3
05. Energy	20	6.4	20.3
06. Industrial production	52	6.7	25.3
07. Health	96	6.9	11.9
08. Agriculture	36	12.6	12.9
09. Education	2	3.0	1.7
10. Culture, recreation, religion and mass media	7	6.1	0.1

SEO	No of Programs 1978-79 to 2019-20	Average Duration (Years)	Average Annual Program Expenditure
11. Political and social systems	95	4.2	2.0
12. General advancement of knowledge	62	8.1	87.6
14. Defence	21	5.7	15.7
Total	483		

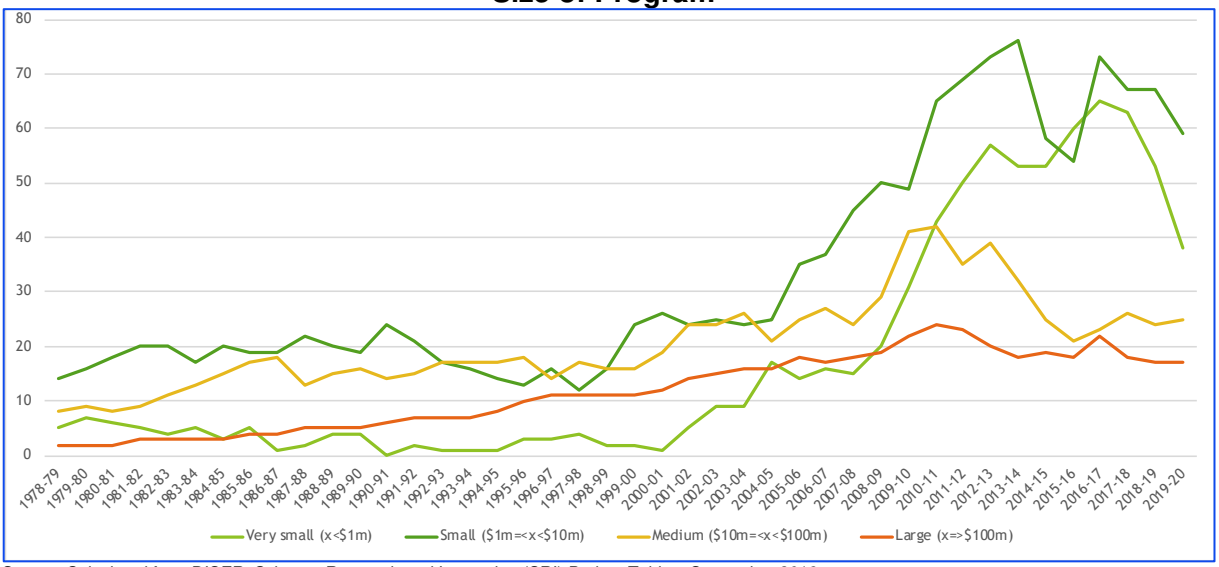
Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

The nature of this dissipated program commitment is unlikely to be efficient or effective in ensuring that resources are flowing to where they are needed most and can deliver the greatest impact. The relative stability of the Multiple categories SEO reflects the inclusion of CSIRO, ANSTO and the ARC, while the stability of the Agriculture SEO is a reflection of the continuity of the Rural Research and Development Corporations (RRDCs).

Analysis of the dataset indicates the range of large, medium, and small programs, with varying lengths of duration. The size and duration of programs varies across SEO categories. Figure 17 indicates that *the number* of small and very small programs has been increasing over time, particularly since 2004-05. The number of medium and large programs have been decreasing since 2011-12.

The increase in the number of small and very small programs and the decline in the number of medium and large programs is indicative of a move towards more "tokenistic" level of support for R&D

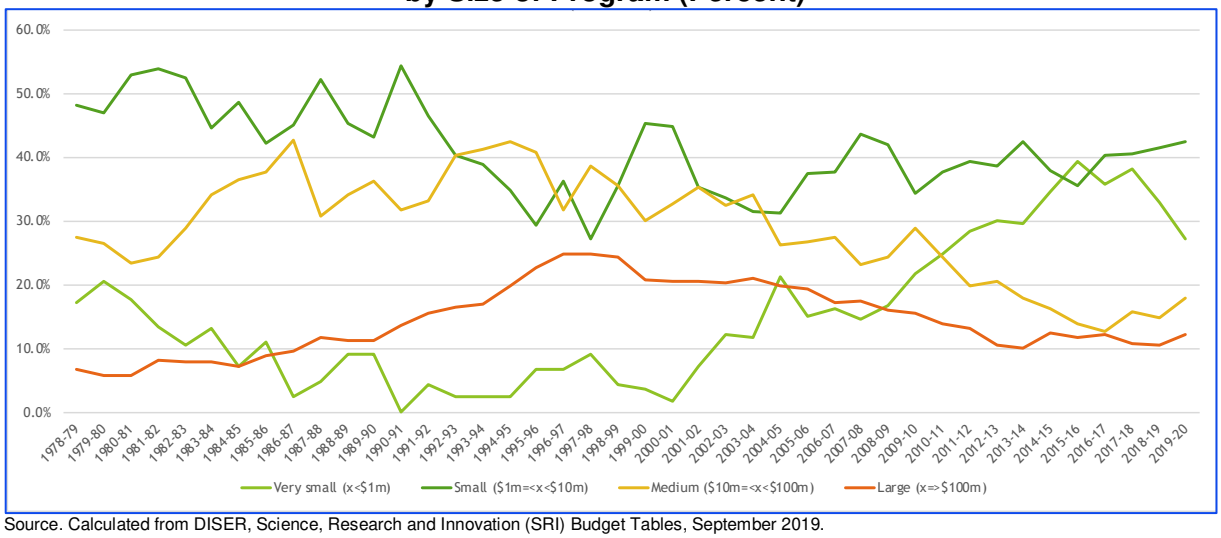
Figure 17: Australian Expenditure on SRI 1978-79 to 2019-20 - Number of Programs by Size of Program



Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

Figure 18 shows that *the proportion* of very small programs has been increasing since 2000-01 while the proportion of large and medium-size programs has been falling.

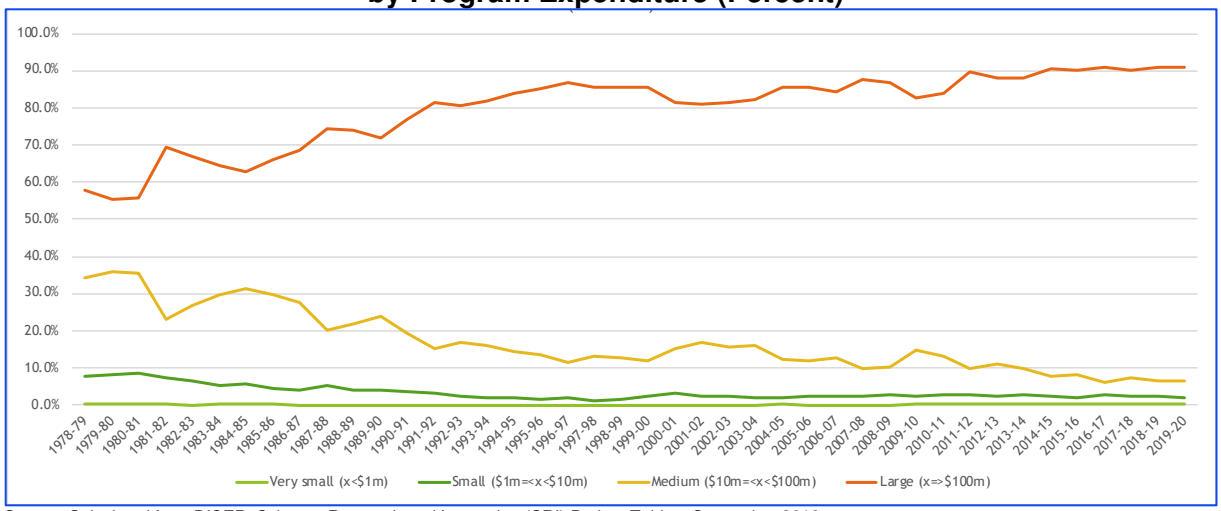
Figure 18: Australian Expenditure on SRI 1978-79 to 2019-20 - Proportion of Programs by Size of Program (Percent)



Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

However, as indicated in Figure 19, when it comes to program expenditure, resources have been going to the *larger programs*, such as the RDTI.

Figure 19: Australian Expenditure on SRI 1978-79 to 2019-20 - Proportion of Programs by Program Expenditure (Percent)



Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

The trend data suggest that, in terms of program expenditure, the larger programs are crowding out the medium size programs. With declining overall support for SRI, this is a matter of some concern.

5.2.3 Expenditure on non R&D related SRI Innovation

The Government has taken a renewed interest in non-R&D expenditure on innovation, reflected in the recent ISA Report *Stimulating business investment in innovation*[28].

Of course, the notion of non-R&D innovation is not new and has been canvassed in the management approach to innovation for 50 years - since the publication of Peter Drucker's classic, *Management, Tasks, Responsibilities, Practices* in 1973. There has been earlier work in Australia, such as BCA project *New concepts in innovation: the keys to a growing Australia*, 2006[29].

The ISA Report makes four strategic recommendations:

1. Government rebalance its policy mix to support business investment in both non-R&D innovation and R&D, specifically with significant additional support for non-R&D innovation for a defined period, say, 5–10 years.
2. Government and businesses prioritise the key growth sectors.
3. Government and businesses develop and encourage a "growth through innovation" mindset and the business processes required to implement this mindset among shareholders, directors, and managers.
4. Government facilitate access to and attraction of innovation skills and capabilities.

These recommendations reinforce policy positions communicated on many previous occasions, and contained in the abundance of government reports, papers and statements on RDI over a 30 year period.

In the context of the ISA insights, the Commonwealth RDI tables now include a dataset on non-R&D expenditure. Collection of this data commenced in 2017-18. The programs included in the dataset either involve no reportable R&D, or else have had their R&D component reported separately in the main R&D dataset. The Publication advises that totals before this date may not be accurate.

A summary of the reported data is provided in Table 8. A more detailed list of programs and activities is provided in Attachment 6.

Table 8: Australian Expenditure on non-R&D RDI 1978-79 to 2019-20 SEO Categories (Inflation Adjusted)

Socio-Economic Objective	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
00. Multiple categories		8.0	10.5	4.5	10.8	9.5	14.5	39.6	78.6	103.4	106.5	87.9
01. Exploration and exploitation of the Earth									1.2	1.3	0.0	0.0
02. Environment			3.6	4.2	4.7	4.3	3.6	4.0	3.5	2.6	1.7	0.7
04. Transport, telecommunications and other infrastructures										9.4	19.2	9.4

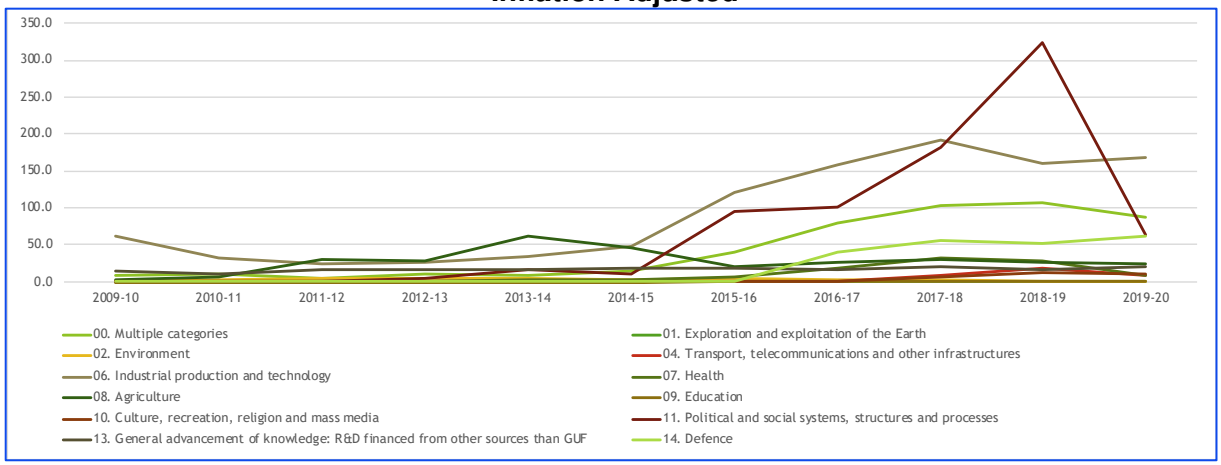
28 https://www.industry.gov.au/sites/default/files/2020-02/stimulating-business-investment-in-innovation.pdf
29 See https://www.voced.edu.au/content/ngv%3A14799. The report highlights that the traditional view of innovation as research and development is no longer appropriate, but that: innovative activity extends across all parts of a business; the imperative to deliver customer value drives the need for, and nature of, innovation; and innovation, in some circumstances, has more to do with human capital than with technology and invention. The following four priorities aimed at strengthening Australia's capacity for innovation are identified: (1) build an understanding of business innovation; (2) advocate the importance of the BCA reform agenda for innovation in Australia; (3) advocate the importance of education and training systems in delivering the capabilities for innovation success; and (4) deliver innovation outcomes by providing the best possible environments for innovation within workplaces. The contents are: Executive summary; Background; What is innovation; Major themes from the Changing Paradigms report; BCA innovation priorities; Main findings.

Socio-Economic Objective	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
06. Industrial production and technology	17.4	61.3	31.8	24.5	25.4	33.9	47.3	121.2	158.2	191.7	160.3	168.4
07. Health							3.5	6.5	18.3	32.1	28.8	9.2
08. Agriculture		3.5	6.0	31.1	28.9	61.5	45.5	20.8	25.6	30.7	25.7	24.3
09. Education								0.1	0.1	0.1	0.1	0.1
10. Culture, recreation, religion and mass media								0.0	0.0	6.1	12.7	10.1
11. Political and social systems, structures and processes					3.9	16.1	9.6	94.9	101.1	183.1	324.4	63.2
13. General advancement of knowledge: R&D financed from other sources than GUF	13.4	15.3	11.0	17.2	17.2	17.0	18.0	18.1	17.5	19.9	15.6	19.7
14. Defence									40.2	55.3	51.2	61.3
Total	30.8	88.0	62.9	81.4	90.9	142.2	141.9	305.2	444.3	635.6	746.2	454.3

Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

The reported data indicates that Commonwealth expenditure on non-R&D based innovation is quite modest compared with R&D expenditures. The trends are represented in Figure 20.

Figure 20: Australian Expenditure on non-R&D Innovation 2009-10 to 2019-20 by SEO - Inflation Adjusted



Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

From 1997-98 the principal SEO category was Industrial Production and Technology, which has continued. Details of expenditure commitments in this SEO are provided in Table 9.

Table 9: Major Program Commitments – non-R&D Innovation Expenditure on Industrial Production and Technology 1997-98 to 2019-20

06. Industrial production and technology	Program Commitment	Years of Commitment	First Commitment Year
Centre for Defence Industry Capability (CDIC) Innovation initiatives	92.6	4	2016-17
Renewable Energy, Energy Security Program	1.3	2	2018-19
Automotive Innovation Labs	9.8	3	2017-18
Business Research and Innovation Initiative (BRII)	23.5	4	2015-16
Competitive Pre-Seed Fund	69.1	8	2002-03
Entrepreneurs' Programme (excluding Single Service Delivery and Innovation Connection Grants)	442.7	6	2014-15
Industry 4.0 Test labs for Australia	5.7	1	2018-19
Industry Growth Centres	23.3	5	2015-16
Industry Growth Centres Initiative - Commercialisation Fund	75.7	6	2014-15
Innovation Investment Fund including Innovation Investment Follow-on Fund	458.5	11	1997-78
Inspiring Australia | Science Engagement Programme	36.1	4	2016-17
Superstars of STEM	1.3	1	2017-18
Victorian Innovation and Investment Fund (Geelong Region Innovation and Investment Fund and Melbourne's North Innovation and Investment Fund)	30.0	4	2013-14
Women in STEM	2.9	2	2018-19
Women in STEM and Entrepreneurship (WISE)	13.7	4	2015-16
	1,286.2		

Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

Table 9 shows the significance of the Entrepreneurs Program and the Innovation Investment Fund Program (no longer operating) and the relatively modest commitments to the Growth Centres Program. Expenditure commitments under these programs are drawing to an end, with no indication of continued Government commitment.

Since 2015-16 non-R&D innovation commitments have cropped up in the following SEOs:

- Political and social systems – includes a large expenditure on digitization of payment processes, totalling $562.9m over the 2015-16 to 2018-19 period.
- Multiple categories - includes Excellence in Research for Australia ($73.4m), Industry Skills Fund ($51.0m), and Embracing the Digital Age ($48.8m).
- Defence - Defence Innovation Hub ($212.3m).

5.2.4 Combined R&D and non-R&D innovation expenditure

The combined totals of R&D and non-R&D innovation expenditure are provided in Table 10.

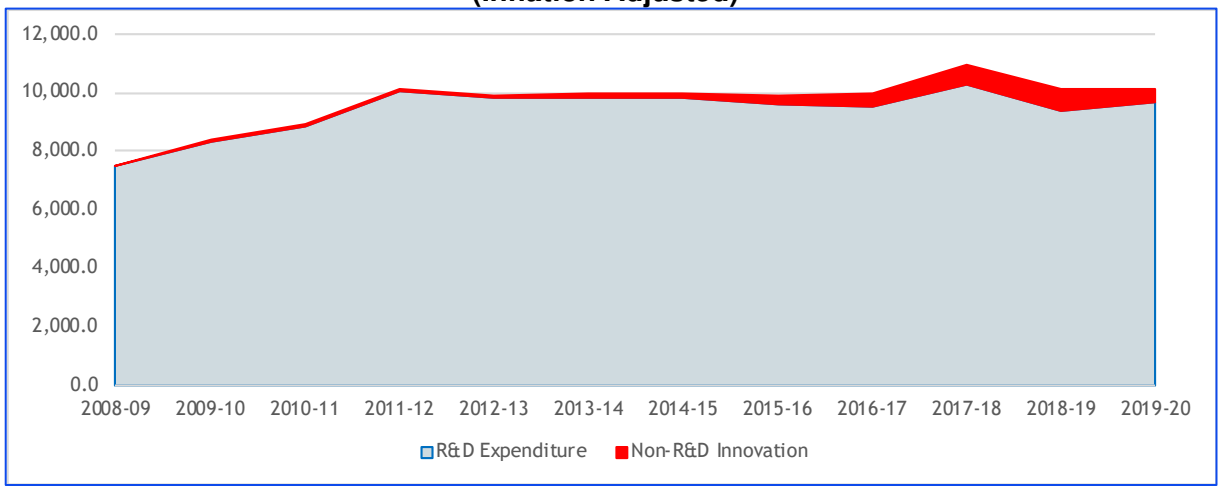
Table 10: Australian Expenditure on R&D and non R&D SRI 2008-09 to 2019-20 (Inflation Adjusted)

Category	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20
R&D Expenditure	7,493.2	8,317.9	8,870.2	10,072.1	9,791.7	9,851.1	9,835.5	9,615.9	9,501.8	10,285.8	9,396.2	9,635.8
Non-R&D Innovation	30.8	88.0	62.9	81.4	90.9	142.2	141.9	305.2	444.3	635.6	746.2	454.3
Total RDI Expenditure	7,524.0	8,405.9	8,933.1	10,153.5	9,882.6	9,993.3	9,977.4	9,921.1	9,946.1	10,921.4	10,142.4	10,090.1

Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

The combined datasets indicate that Commonwealth RDI expenditure, in inflation-adjusted terms, continues to decrease from a peak reached in 2017-18. The trend is shown in Figure 21 below.

Figure 21: Australian Expenditure on R&D and non R&D SRI 2008-09 to 2019-20 (Inflation Adjusted)



Source. Calculated from DISER, Science, Research and Innovation (SRI) Budget Tables, September 2019.
https://www.industry.gov.au/sites/default/files/2019-09/2019-20-sri-budget-tables.xlsx

5.2.5 Implications of the data

Apart from the declining commitment to investment in Research, Development, and Innovation, the data presented in this section point to some worrying trends. These support earlier analyses in this Paper.

The resources available for expenditure on RDI are determined by decision processes of a number of research councils and other budgetary resource allocation processes.

There are three Research Council frameworks with a specific R&D remit for independent, objective, and transparent decision making, and well documented processes and procedures. They are:

- The NH&MRC – the NH&MRC has established a strong track record and reputation for supporting health and medical science since its founding in 1932.
- The Australian Research Council - the ARC is thinly spread across all research fields, and its budget allocations are falling. There is very little constituency support outside universities. But it is essential to keep a university focus.
- The 15 Rural Research and Development Corporations – which focus on farming, with a particular crop or livestock focus determined by levy-payers. The RDC framework is currently under review.

The proportion of R&D funding available through these Research Council processes has risen from 6.6% in 1989-90 to 12.2% in 2019-20. The proportion of total R&D expenditure allocated through the NH&MRC has increased from 3.7% in 1989-90 to 9.0% in 2019-20. *However, only 3.2 % of R&D expenditure is allocated through the other research councils in 2019-20*.

A substantial proportion of research expenditure (87.8%) is allocated from decisions made under a wide range of public administration and political processes. These include:

- The well-established and now settled frameworks of the publicly funded research agencies (CSIRO, ANSTO, and DSTO)
- The highly respected Cooperative Research Centre (CRC) framework, operating since 1991-92
- Open and transparent formulae, such as for the university Performance Grants Scheme (although formulae can be exceptionally complex)[30]
- More opaque submission-based criteria approaches to access designated “funding programs”
- Ministerial discretion, with advice sourced from Departments and Ministerial staff
- Informal one-off grants arising from advocacy and lobbying.

The less formal the arrangement offer more scope for duplication, overlap, and double-dipping by grant applicants across programs, Departments, and Governments. Programs are less likely to be efficient or effective. Resource allocation would be improved if allocated through formally established Research Investment Councils established under recognised governance

[30] These programs can be the subject of “gaming” where weak links in the formulae are discovered.

principles and targeted at areas that will be expected to assist Australia to make the transition to new sources of growth and prosperity.

It is an argument of this Paper that a much greater proportion of RDI funding should be allocated by formally constituted Research Councils operating at arm's length from Ministerial discretion, and fully accountable for allocation decisions.

A number of new Research Councils should be established to address the unique R&D characteristics of distinct industry sectors and promote the development, application, and use of breakthrough research that addresses Australia's transition away from a "frontier", resource extraction-based economy to a "new" economy with a robust commitment to the creation and application of knowledge.

The Councils would give research national meaning and focus – drawing on the model of the NH&MRC and the way it has been at the foundation of growing Australia's Health and Social Assistance industry – Australia's largest employer.

Requirements for Research Investment Councils are particularly urgent in the following industry categories -

1. Land, Water, and Climate Change – Abolition of Land and Water RDC was later admitted by the responsible Minister to have been a mistake
2. Energy and Resources – including renewable energy
3. Transport, Communications, and Infrastructures – desperately in need of a strong R&D commitment in the light of change and disruption that is occurring in these industry sectors.
4. Industrial Production and Technology – to provide prominence to research in manufacturing and related manufacturing technologies and work with the many smaller and shorter-term initiatives, such as the Advanced Manufacturing CRC. A major commitment is required for non-R&D innovation.

Research in these areas is currently lacking a national focus and is dissipated across many research programs – or not undertaken at all.

The roles and functions of the Councils require further detailed consideration, but the principles outlined are an important starting point.

5.3 Addressing the collaboration imperative

Australia's performance in university-business collaboration is rated among the lowest in the world. The measured performance may be impacted to some extent by Australia's very high level of research investment in health and medical research and the significance of *public sector-university* collaboration (for example, public hospitals collaborating with medical faculties and research institutes). But this does not let innovation and industrial policy off the hook.

5.3.1 Foundations for success

Fifteen years ago, acclaimed innovation researcher Lew Branscomb observed that the key to success in university-industry partnerships depends very much on the primary motive of each partner:

> If the universities value the partnership as a means of exposing faculty and students to leading-edge technical issues that are driving innovations of benefit to society and are not basing their expectations primarily on revenues from patents, a stable, productive relationship may endure. If the firms see universities as sources of new ideas and as windows on the world of science, informing their own technical strategies, rather than viewing students as a low cost, productive source of near-term problem solving for the firm, they too will be rewarded. Each partner must understand and accept the other's priorities. The money and services exchanged should be seen as the means to broader ends (Branscomb, 2003).

Effective and long-term collaboration occurs when there is the *capacity* for collaboration, including shared interest and purpose, commitment to outcomes, and high levels of trust between parties. This basis for collaboration is acknowledged to take many years to develop. The capacity for universities to collaborate is also influenced by the depth of their research and knowledge base.

5.3.2 Long term commitment

Early parts of this Paper have pointed to Australian research strengths, in terms of research outputs, in Medical and health sciences, Engineering, Biological sciences, Chemical sciences, and Psychology and cognitive sciences. The Paper has also made the point that collaborations are long term investment relationships and may not be indicated by annual financial transactions between the parties.

Transactional relationships, which essentially amount to “merchandising knowledge”, are economic transactions rather than collaborations. They tend to reflect a “commodity” approach to knowledge – reflective perhaps of Australia’s commodity culture (and an economist’s view of knowledge and technology as a factor of production).

In the US much more attention has been given to the framework of the *University Research Centre* (URC) as a vehicle for university-industry collaboration. During the late 1980s and early 1990s several government inquiries called for the establishment for multidisciplinary research centres and, as a result, both the NIH and NSF increased support from comprehensive centres that combined research with clinical trials, technology transfer, and education.

Many of the new US research centres that were created in the early 2000s focussed on new fields such as nano-technology, nano-scaled science, biomaterials, lasers, photonics, environmental ecosystems, supercomputing and biomass convergence to biologically safe fuels.

The US URC framework became a major university mechanism for undertaking large, complex research projects. They are seen to be highly adaptable to undertake research projects for industry and defence applications.

The research centres have modified the single-discipline approach to research and training and focussed on multi-disciplinary research that better suits the needs of industry.

A recent trend has been for large business enterprises to enter into *long-term developmental research agreements* with universities that involve "umbrella agreements" with mechanisms for the selection of specific projects. Proprietary considerations, principally involving patent rights and rights to publication, tend to be rather detailed and complex and require formal mechanisms for management and review. Telstra once had such an arrangement.

The Australian Research Council has recently assessed evidence not just of university research quality but also "engagement and impact".[31] This often takes the form of university-industry cooperative research centres. The CRC Program has produced a small number of enduring research centres – that outlasted the government funding.

Outside the CRC Program, there are few incentives for universities and industry to commit to long term collaborations. Though useful and sometimes catalytic, the ARC Linkage program tends to be more transactional and short term, and the effectiveness of the more recently established ARC Industrial Transformation Research Hubs and Training Centres has yet to be evaluated.

An Advanced Engineering Centres Program operated in the 1990s, but in typical fashion, it was closed down early in its life[32]. More recently, the CSIRO's Data61 initiated the *Sixth Wave Alliance* "to develop a national robotics R&D strategy and create the critical mass required to address large-scale Australian and international challenges using robotics technologies".[33] The approach being taken would appear to have a stronger chance of achieving critical mass and longevity.

5.3.3 Management matters

There is still quite limited knowledge and understanding in Australia of what drives success in terms of governance and leadership, organisational frameworks, systems and processes, and relationships with the Executive of a host university in establishing collaborative arrangements.

A visionary strategy is vital, but unless the management framework, including shared interests and incentives for collaboration, is given appropriate attention, achieving outcomes will continue to be a difficult challenge.

This Paper proposes the formation of a major commonwealth RDI investment program to invest in "the industries of the future" – the engineering and technology-based industries that transcend the industrially defined industries. (See Section 6.3 on page 58) The program would be at scale and support six state-based *Advanced Engineering and Technology Research Institutes* over a minimum period of 10 years with provision for renewal.

[31] See https://www.arc.gov.au/engagement-and-impact-assessment
[32] The National Collaborative Research Infrastructure Strategy has been an important initiative to provide research facilities for use and access by participating research organisations, such as The Australian National Fabrication Facility (ANFF). But the Strategy is not a vehicle delivering national high priority multidisciplinary research projects in a standalone research centre.
[33] See https://www.csiro.au/en/News/News-releases/2018/Sixth-Wave-Alliance-to-accelerate--Robotics-and-Autonomous-systems-RandD

5.4 Towards place-based strategies

Geographic clustering of economic activity has been of interest to economic geographers for many decades. Management academic Michael Porter brought it to prominence from an innovation perspective in *Clusters and Competition* (Porter, 1998). It was followed by a series of studies supported by the US Council on Competitiveness in areas such as the Green Triangle (Porter, 2001a), San Diego (Porter, 2001b), and Pittsburgh (Porter, 2002).

From 2012 the OECD and the EU have supported the adoption and implementation of Regional Innovation Smart Specialisation Strategies (OECD, 2013, OECD, 2012, Charles et al., 2012). Smart Specialisation is embedded in the current EU Cohesion Strategy (McCann and Ortega-Argiles, 2014) and has been widely implemented across the European Region and UK.

In 2014 the Brookings Institution supported a research project, *Rise of Innovation Districts: A New Geography of Innovation in America* (Katz and Wagner, 2014). This and similar policy research exercises have had a substantial impact on innovation thinking throughout the world.

In 2018 the NSW Government released a report, *NSW Innovation Precincts: Lessons from International Experience* (NSW Innovation and Productivity Council, 2018) which explores the factors that contribute to successful, globally-significant innovation precincts as well as common risks and failures, to support successful precinct development in NSW. The Australian Government has also recently published a policy paper on innovation precincts *Statement of principles for Australian innovation precincts* (Department of Industry Innovation and Science, 2018).

Innovation precincts are emerging in Sydney around universities – Ultimo (UTS), Parramatta (WSU), Eveleigh (University of Sydney). In February 2019 the NSW Government adopted the recommendations of a Panel led by the Chair of Jobs for NSW, *A Vision for the New Sydney Technology and Innovation Precinct* (The Sydney Innovation and Technology Precinct Panel, 2018). The Greater Sydney Commission is supporting the formation of health and education precincts[34].

Essentially, location-based policy initiatives are concerned with generating knowledge spill-overs. From an innovation effectiveness perspective, knowledge spill-overs explain both why geographical clusters of firms and innovative activity exist.

It is known, for example, that a start-up firm in a cluster with strong knowledge spill-overs is more likely to succeed commercially than one located in a weaker cluster. This is because better face-to-face advice is available to help start-ups avoid the myriad of risks confronted.

This perspective can explain why the 'serial entrepreneurs' found in high-performing innovation clusters play such an important role in helping to spot new business opportunities and in driving down the investment risks faced when innovating (Matthews and Lacy, 2017).

[34] See https://www.greater.sydney/north-district-plan/productivity/jobs-and-skills-city/growing-and-investing-health-and-education

The business advice is most often sourced from independent, experienced, and trusted mentors and intermediaries. The availability of this capability is an essential ingredient in incubators and co-working spaces located in cluster arrangements (Howard, 2017, Howard, 2015).

Knowledge spill-overs are a particularly important aspect of *Global Value Chains* (GVCs) and *Global Innovation Networks* (GINs) because global inter-firm transactions create opportunities for knowledge transfers to take place. Large technologically sophisticated multinational corporations, often "anchored" in precincts, deliberately cultivate knowledge spill-overs because they strengthen the competitiveness of their GVCs (Matthews and Lacy, 2017). Around the world, universities and public research agencies are also active participants in GlNs – in part because of their location in an innovation cluster, district, or precinct.

As McKinsey argued many years ago, the future of Australian innovation and industrial strategy is to act local, think global. This has particular importance in a context of globally focussed high growth firms and globally oriented startups operating in innovation precincts and districts.

Since the effective winding back of the Commonwealth from the innovation policy space in 2013, universities became more engaged with their regions. They have emerged as key players in support of the development of regional and local innovation ecosystems in the cities and regions where they are located. They have also become significant urban developers and renewal agents through co-investment in buildings, facilities, and services related to research, learning, and student amenity. The growing sophistication of public-private-partnerships (PPPs) has assisted in this process.

Universities are also being more active participants in cluster development and operation rather than passive landlords in real estate development plays. They are active promoters and facilitators of collaboration between the university and business organisations, as well as being champions of startups and incubators. These knowledge clusters are said to become "magnets" for businesses, entrepreneurs, students, and city dwellers.

Place-based innovation initiatives provide the foundation for building personal relationships and trust that are essential and fundamental to collaboration.

On 2 March 2019 the UTS Deputy Vice-Chancellor (Innovation & Enterprise) reported:

> The Premier of NSW announced formation of the Sydney Innovation and Technology Precinct and an intention by Atlassian to relocate their company headquarters near Central Station. The development of a Technology and Innovation Precinct focussed around Central Station and extending to Eveleigh is very exciting for UTS and aligns beautifully with our UTS 2027 strategic initiative "Our precinct, community and partnerships" to "Lead and drive the development of a world-class innovation precinct in collaboration with the State Government and other partners".

The Melbourne Bio21 Initiative is also an excellent example of an innovation district and an enduring collaboration between the University of Melbourne, research institutes and a global

corporation. An agreement was signed to extend the initiative in December 2018. A brief profile is provided in Attachment 1. The University is also in the Melbourne Connect precinct consortium. The University of Tasmania recently announced that it is engaging business and industry with plans to create a defence and innovation precinct alongside the Australian Maritime College (AMC) at its Launceston Newnham Campus.

An Innovation precinct is emerging at Geelong in the Deakin University campus, and the Tonsley Park initiative is actively supported by Flinders University. The University of Wollongong hosts a thriving innovation precinct[35]. Many of these innovation precincts are associated with urban renewal agendas. The Wollongong strategy includes a significant health and well-being component, as does the strategy at University of Canberra. Charles Sturt University hosts the AgriPark initiative on its Wagga campus.

The Commonwealth *City Deals* initiative, which operates outside the Innovation and Industry portfolio, has supported several significant place-based innovation initiatives involving the active participation of universities.

[35] The University of Wollongong has a long history of collaboration with BlueScope Steel, which is outlined in Attachment 1.

6 New Policy Directions

Set out below are some thoughts on how to address the dissipated orientation and lack of strategic direction in Australia's limited support for Science, Research, and Innovation.

6.1 Establish four new Research Councils in national socio-economic priority areas

As argued in Section 5.2.5 above (page 50) there is an urgent requirement to bring together RDI effort into a number of strategic priority areas. The Growth Centres Initiative goes some way but does not address the full framework of transitioning to new sources of growth. They could be an essential element of what is proposed here.

To address the transition to new sources of growth requirements for clearly focussed strategic long-term research commitments, new Research Investment Councils are proposed for the following four industry categories:

1. *Energy and Resources* – including renewable energy. The Council would be responsible for directing and resourcing RDI that would deliver on the national mission of net zero emissions by 2020.
2. *Land, Water, and Climate Change* – Abolition of Land and Water RDC in 2009 was later admitted by the responsible Minister to have been a mistake.
3. *Transport, Communications, and Infrastructure* – desperately in need of a strong R&D commitment.
4. *Industrial Production and Technology* – to give focus to research in manufacturing and work with the many smaller and shorter-term initiatives, such as the Advanced Manufacturing CRC. The Council would be expected to make a significant commitment to non-R&D innovation, such as in the design area.

RDI effort in Culture, recreation, and media, and Political, economic, and social systems (where there are currently 27 separately operating research programs) would be coordinated through the existing ARC framework.

The governance, roles, and functions of the Investment Councils require further detailed consideration, but the principles are important. The following matters would need to be considered:

- Development of investment strategies in consultation with industry, research organisations, and governments
- Membership drawn from research, industry and government sectors
- Operate with broad Ministerial charters – and accountable to a Minister
- Staffing independent of public service oversight

6.2 Establish a Ministerial Council on Research, Science and Innovation

To coordinate, guide, and provide an avenue for *cross-portfolio* ministerial accountability for the Research Investment Councils, a Ministerial Council on Research, Science, and Innovation should be established. It would consist of all Ministers with portfolio responsibilities that relate to Science, Research, and Innovation.

Council membership would include, but not be limited to, the Prime Minister, the Ministers for Industry, Science, Energy and Resources, Health, Agriculture, Environment, Minister for Infrastructure, Transport and Regional Development, and Defence. It could also include the Minister with responsibilities for Arts and Creative Practice.

The Research Investment Councils would work under the strategic guidance of a Ministerial Council on Science, Research and Innovation

The National Science and Technology Council[36] would advise the Research Investment Council. The Chairs of the Research Investment Councils would form a Standing Committee of the Ministerial Council.

6.3 Initiate a major investment commitment to RDI in new industry technology areas.

A national investment program is required to lift RDI capability in "new industry" technologies that transcend all of the classically defined industry areas. These technologies, which have a strong engineering focus, include microprocessing and sensors, big data and analytics, robotics, automation, autonomous transport, nanomaterials, artificial intelligence, simulation, and visualisation, and energy capture, storage and transmission.

The Investment Program would support six state-based collaborative Engineering and Technology Research Institutes (NSW to include the ACT, SA the NT).

The envisaged Engineering and Technology Research Institutes would be expected to:

- Closely interact with the Research Investment Councils referred to above to address specifically the imperative to lift productivity and transition to new sources of growth.
- Operate under a Deed of Agreement, with a guaranteed life of 10 years, with an option for renewal.
- Collaborate across all universities *and TAFEs* in the State.
- Not waste too much time looking for industry co-contribution in set up – but fee for service arrangements would be established – examples of overseas RDOs, Fraunhofer Institutes, etc

In operation -

- Each institution to present a strategic investment plan
- Look for nuances across States and incorporate State priorities
- No attempt to allocate proportionate amounts on a State by State basis
- Ensure consistency with other Investment programs – e.g. Rural RDCs
- Regular review and evaluation.

[36] https://www.chiefscientist.gov.au/national-science-and-technology-council

The initial investment commitment should be $5 billion over ten years.

6.4 Create more effective "institutions for RDI engagement" between sectors

Both the Commonwealth and the States/Territories have invested resources to promote university-business collaboration through initiatives such as innovation intermediaries and vouchers for small businesses to purchase university RDI activity. Many of these are small scale and do not build up a longer-term commitment or relationship.

Arguments for Government to make "third stream", or engagement, funding available to universities to support the cost of industry, innovation, and economic development activities have been around for many years. But the arguments have never really taken hold in policy.

The failure to get serious third stream funding off the ground probably reflects the "silo" approach in public policy – where Education Departments see their role as investing in Education and Research, while industry and economic development roles are handled – and should be funded – elsewhere.

Universities have appointed PVCs and Directors for engagement to build relationships with business, industry, and regions. But their KPI is most often the amount of income generated for the University. At the very least, engagement projects must be self-financing.

From an industry strategy and innovation policy stance, funding to support university engagement activities should rest either with the regional economic development portfolio and/or the Industry portfolio – and of course, the many other portfolios with an industrial strategy and innovation policy remit. To that end, supporting business and industry engagement should be a clear mandate of Innovation and Science Australia.

Innovation and Science Australia should be tasked with developing an industry-university- research organisation engagement strategy.

6.5 Encourage university research investment to align more closely with industrial strategy

An argument of this Paper is that university and industry investment in R&D should be more closely aligned. It is argued that university commitment tends to be where the money is, which is more abundant in Medical Research, while private industry has priorities in engineering and technology areas. It is also argued that industry underinvests in areas that are important to transitioning to new sources of growth.

The proposals in 6.1. 6.2, and 6.3 above should go part of the way to addressing this issue.

6.6 Develop and implement a national place-based innovation strategy

States and Territories (particularly NSW, Victoria, Queensland and the ACT) are actively perusing place-based innovation strategies around regions, districts, precincts and hubs.

There does not appear to be much learning or collaboration between the States/Territories in building capacity and capability. Even within States, there is competition between regions – with the result that there is likely to be an oversupply of innovation centres and hubs. Moreover, regions within States are implementing their own take on the well-established European model of Smart Specialisation Strategies, without national guidance regarding best practice.

There should be scope for developing a "hub and spoke" approach to the formation and operation of innovation centres and hubs.

The Commonwealth can take a national leadership role, but not pre-empt the States. It can also provide:

- Seed or start-up investment
- Research into best practice, and disseminate research results
- Be a Clearing House
- Provide strategic support

Under recent arrangements support for placed-based innovation initiatives have been sourced incidentally for other programs, such as "City Deals". Ministers can be quite adept at finding spare funding buckets to support politically attractive projects – but this draws away from program delivery in a context of clear missions, objectives, and delivery arrangements.

In the interests of achieving greater focus in place-based innovation initiatives, the Commonwealth should bring together the disparate elements of regional strategy, industrial strategy - including sector based strategies, education and skills strategy, into an integrated approach that addresses the outcomes sought by place-based initiatives.

Attachment 1: Case examples of collaboration in areas of high research output

This Attachment provides examples of collaborations across Fields of Research which have high research outputs.

1. BlueScope and University of Wollongong

BlueScope and University of Wollongong

The University of Wollongong's partnership with BlueScope and its predecessors Australian Iron and Steel (AI&S) and BHP Steel dates back to its very earliest days.

The need to train technical staff for BHP's Port Kembla Steelworks was one of the prime reasons for the establishment in 1951 of a Wollongong division of the NSW University of Technology (later UNSW).

That grew into the Wollongong University College, with a central role to train metallurgists and other technical staff for the Steelworks through the 1950s and 1960s. As well as investing a substantial amount – along with community and government donations – to establish the college, BHP also donated tracts of land and building materials, while also funding the salary of the College's first Professor of Metallurgy.

Since then the steel industry and the University of Wollongong (UOW), which became an autonomous institution in 1975, have maintained a close relationship through research partnerships, traineeships, scholarships and collaboration on a wide range of industry and community projects.

One of these research partnerships included the BlueScope Steel Metallurgy Centre (BSMC), which was established in 2004. A key goal of the BSMC was to build up specialised equipment infrastructure shared by UOW and BlueScope employees in a unique arrangement.

This infrastructure supported several collaborative research projects, one of which was at the heart of the development of BlueScope's flagship range of COLORBOND® steel-painted products.

Research teams at BlueScope Steel Research and UOW's School of Chemistry used state-of-the-art mass spectrometry to monitor chemical processes within the paint at a molecular level, to better understand the durability of the paints used in the COLORBOND® range.

STEEL RESEARCH HUB

Another significant initiative of the UOW-BlueScope partnership is the new Australian Research Council Research Hub for Australian Steel Manufacturing (Steel Research Hub), a focussed collaborative initiative drawing together proven and internationally recognised research talent with their industrial counterparts, across the entire steel manufacturing chain.

This partnership aims to develop and ultimately deliver innovative solutions and breakthrough technologies in steel, providing the manufacturing sector with uniquely competitive processing methodologies and differentiated end-user products.

This ground-breaking initiative, which effectively began in 2015, has attracted funding of almost $13 million over five years, including significant investments from the Australian Research Council (ARC) and BlueScope. This demonstrates the value that both industry and government place in collaborative, cross-disciplinary research.

Led by the UOW, the Steel Research Hub brings together key partner, BlueScope, with Arrium, Bisalloy, Stockland, Cox Architects, Australian Steel Institute, Lysaght and the University of Queensland, University of Newcastle, Swinburne University of Technology, RMIT and Monash University.

Each of its research programs involves managing innovation across the steel industry, with specific activities in Market-Focused Product Innovation, Innovative Coating Technologies and Sustainable Steel Manufacturing.

Each of these programs include an Academic and an Industry lead, supporting a team of chief investigators, partners and research students – meaning that industry needs can be addressed in a joint effort of expertise and commercial experience.

Critical projects include to increase abrasion resistance of steel plate, support steel product developments, develop anti-microbial coating systems and to support Australia's competitiveness in steelmaking, both economically and environmentally.

SUSTAINABLE BUILDINGS RESEARCH CENTRE

The Sustainable Buildings Research Centre (SBRC) is a 6 Star Green Star- Education Design v1 accredited, multi-disciplinary facility that hosts a wide range of research and industry collaborations to address the challenges of making buildings sustainable, in particular pioneering approaches to retrofitting techniques to create more effective places to live and work.

Located at the UOW's Innovation Campus, this beautiful new centre is alive with student research as a 'Living Laboratory' and thrives on collaboration with industry. The building was designed and constructed based on the principles of the Living Building Challenge, pushing the boundaries of sustainable design and construction with hopes to inspire communities throughout Australia to take action on sustainability.

BlueScope has played a key role in the SBRC, with a focus on producing innovative new building materials and systems.

The development of Photovoltaic Thermal (PVT) systems, for example, has led to the successful completion of a range of important and productive SBRC-BlueScope projects. The first prototype PVT system was installed as a working demonstration on the SBRC building forming part of the SBRC 160kW renewable energy generation system.

Subsequently BlueScope secured funding from the Australian Renewable Energy Agency, in partnership with SBRC and the Fraunhofer Institute (the largest research organisation in Germany) to further develop the PVT technology and other complementary technologies.

The BlueScope-SBRC team, together with UOW students, also developed the photovoltaic-thermal system that is now installed on the world beating Team UOW 'Illawarra Flame' Solar Decathlon House.

Team UOW was the first Australian team to gain entry to one of the international Solar Decathlon competitions, and took out first prize with their retrofitted, modular, net-zero energy Australian 'fibro' home in the Solar Decathlon China 2013 competition.

Bluescope was the 'Gold Pillar Sponsor' of the UOW Solar Decathlon campaign, which was a key catalyst for the collaborative PVT research and included the development of the award-winning Team UOW/BlueScope Solar Assisted HVAC (heating, ventilation and air-conditioning) System.

SBRC research projects include developing sustainable building technologies for residential and commercial applications, analysing and improving thermal design for buildings to reduce the need for using energy for heating and cooling, and developing control and sensor technology to improve building performance.

As well as its key partnership with BlueScope, partners of the SBRC include the NSW Office of Environment and Heritage, Daikin Australia, Warrigal, TAFE Illawarra, among others.

https://www.uow.edu.au/research/partnersforimpact/UOW236550.html

2. Bio21 Institute of Molecular Science and Biotechnology, University of Melbourne

New BioMedical Research Facility Secures Victoria's Place as World Class Research Destination

The Honourable John Brumby AO today formally opened the new 'Nancy Millis' building, an expansion of the Bio21 Institute of Molecular Science and Biotechnology, University of Melbourne, incorporating CSL's Global Hub for Research and Translational Medicine.

"This is an important industry-university partnership that will enable greater knowledge and technology transfer, drive innovation and ensure Australian research is translated into positive health outcomes around the world," said Mr Brumby.

The state-of-the-art, $46million research facility expands the footprint of the Bio21 Institute by 5000 square metres and will house the University of Melbourne's Margaret Sheil Mass Spectrometry laboratories, CSL's Global Hub for Research and Translational Medicine and shared meeting spaces.

The Bio21 Institute is one of the University's flagship research institutes, and for more than a decade has played an important role in positioning Victoria and Australia as a leading destination for life sciences and biotechnology research.

CSL is the largest investor in biomedical Research and Development in Australia. In FY2017-18, the company invested more than US$702 million (~A$900 million) globally in R&D, backed by an R&D workforce of approximately 1700 people worldwide. With the opening of the new facility, CSL expects to more than double the presence of its research scientists at Bio21, from 75 to around 150.

"Universities, government and industry are crucial partners in building and enhancing Australia's innovation ecosystems. This collaboration within a shared facility is a great example of the kind of partnerships we want to encourage," said Mr Brumby.

The building will enable the expansion of major technology platforms that underpin personalised medicine and the development of new diagnostics.

"Bio21 is delivering a world-class research facility for Australia that will play an important part in advancing biomedical research knowledge and the development of new therapies," said University of Melbourne Vice Chancellor, Duncan Maskell.

"It provides a concentration of key infrastructure for researchers from the University and from neighbouring organisations, including medical research institutes and hospitals within the Melbourne Biomedical Precinct.

"The new facility will help researchers to develop diagnostics and treatments for cancer, infectious, metabolic, autoimmune, neurodegenerative and other diseases.

"The co-location of a large multi-national company with the University is a fundamental aspect to the facility's success and will generate an environment in which other start-ups and small businesses can thrive," said Professor Duncan Maskell.

https://www.csl.com/news/20181214-nancy-millis-building-opens-at-bio21-institute-press-release

3. Macquarie University and Cochlear

Macquarie University and Cochlear re-sign partnership

Professor David McAlpine, Director of Hearing Research at the Australian Hearing Hub, with NSW Minister for Trade and Industry, Primary Industries and Regional Water, Niall Blair

Macquarie University supports Cochlear on a range of activities and its partnership is formalised under a memorandum of understanding, which was re-signed on 11 June for a duration of five years.

Vice-Chancellor Professor S Bruce Dowton says the partnership between Macquarie University and Cochlear showcases true interdisciplinary collaboration.

"By 2050 over 900 million people will have a disabling hearing loss. We and our partners are investing in our people and partnerships on a grand scale to address an issue that has significant implications for wellbeing, communication and cognitive health. We are affecting change by working with the WHO, Governments, Industry and other academic partners to help address this major health priority," says Professor Dowton.

Together, Macquarie University and Cochlear are in agreement on the potential for NSW to export its hearing expertise in technology, research and translation, clinical practice (pre-clinical and clinical trials), education, training, and professional development, with a strategic focus on China.

Initial steps to communicate this strategic intent with the state government occurred on 25 June, with NSW Minister for Trade and Industry, Primary Industries and Regional Water, Niall Blair visiting the headquarters of Cochlear to tour the manufacturing of its latest technologies and discuss plans for an investment growth push into China.

As part of his visit, Minister Blair also toured the anechoic chamber, located within Macquarie University's Australian Hearing Hub, where some of the country's leading hearing and healthcare organisations collaborate with researchers on ground-breaking research projects to deliver integrated care across clinical disciplines.

Cochlear Chief Financial Officer Brent Cubis says the World Health Organisation estimates 96 million people in China have disabling hearing loss creating a strong market opportunity for Australia's hearing expertise.

"Cochlear is also collaborating with the Sichuan Innovation and Entrepreneurship Promotion Association to promote a new co-located, multi-disciplinary hearing health precinct – the Sino-Australia International Hearing Hub – modelled on the Australian Hearing Hub at Macquarie University. It will host a range of hearing health-related organisations to facilitate collaboration and to assist in improving access to hearing healthcare," says Cubis.

https://www.mq.edu.au/thisweek/2018/07/06/macquarie-university-and-cochlear-re-sign-partnership/#.XH4FalMzZTY

4. SMaRT@UNSW

SMaRT@UNSW

Sustainable Materials Research & Technology

Founded in 2008 by ARC Laureate Fellow Scientia Professor Veena Sahajwalla, the Centre for Sustainable Materials Research and Technology (SMaRT) at the University of New South Wales works with industry, global research partners, not-for-profits, local, state and federal governments, on the development of innovative environmental solutions for the world's biggest waste challenges.

Based out of the Faculty of Science, the SMaRT Centre brings together researchers from the faculties of Science, Engineering, and the Built Environment. The centre has 30 personnel, state-of-the-art furnaces and laboratories, and sophisticated analytical and processing equipment. Combining the distinctive research capabilities of UNSW's academics, the SMaRT Centre has a track record of delivering research and technology suitable for rapid implementation.

The core aims of the SMaRT Centre are to develop novel research for sustainable materials and manufacturing processes, build industry partnerships to activate research for real world impact, and to disseminate green materials and manufacturing technologies that benefit industries, local communities, and enhance sustainable economic growth internationally.

UNSW has developed the world's first 'microfactories' to take all of the recycled containers and materials put out in council bins, along with other waste streams, and convert them into materials such as metals alloys, plastic filament for 3D printing, and glass panels for building products.

5. The UTS Centre for Autonomous Systems

The UTS Centre for Autonomous Systems

The UTS Centre for Autonomous Systems (CAS) is an internationally acclaimed robots research group. We specialise in robotics research that creates positive change for government, industry and the wider community. Our researchers undertake a comprehensive program of fundamental, applied and translational research, and form key industry partnerships based on the real-world application of our work.

We have a growing reputation in both academia and industry for developing innovative enabling technologies that seek to:

- improve worker health and safety
- increase workplace productivity and output quality across a range of sectors
- assist people with health conditions and disabilities to engage more fully with life

UTS Centre for Autonomous Systems (UTS:CAS) consists of 56 staff and research students with a fundamental research focus on three key problems in robotics: "Robots in unknown and complex environments", "Assistive Robotics and Human robot interaction" and "Robot Teams".

From 2003 - 2010, it was one of the three nodes of the ARC Centre of Excellence for Autonomous Systems (ARC CAS). With over 230 staff and research students, ARC CAS became the second largest robotics research group in the world with an international reputation for both leading fundamental research and its application to industry.

UTS:CAS has a history of delivering high impact industry outcomes, particularly through our work on autonomous grit-blasting robots, bio-inspired autonomous climbing robots and smart hoists.

- Two autonomous grit-blasting robots now in service with grit-blasting crew at the Sydney Harbour Bridge.
- UTS Start-up "SABRE Autonomous Solutions".
- Smart hoist for patient handling.
- Bio-inspired autonomous climbing robot deployed for underwater inspection of the Sydney Harbour Bridge

https://www.uts.edu.au/sites/default/files/Brochure.pdf

Attachment 2: Additional Tables and Charts

Figure 22: Proportion of Countries' Research Investment Allocated to Specific Fields of Research

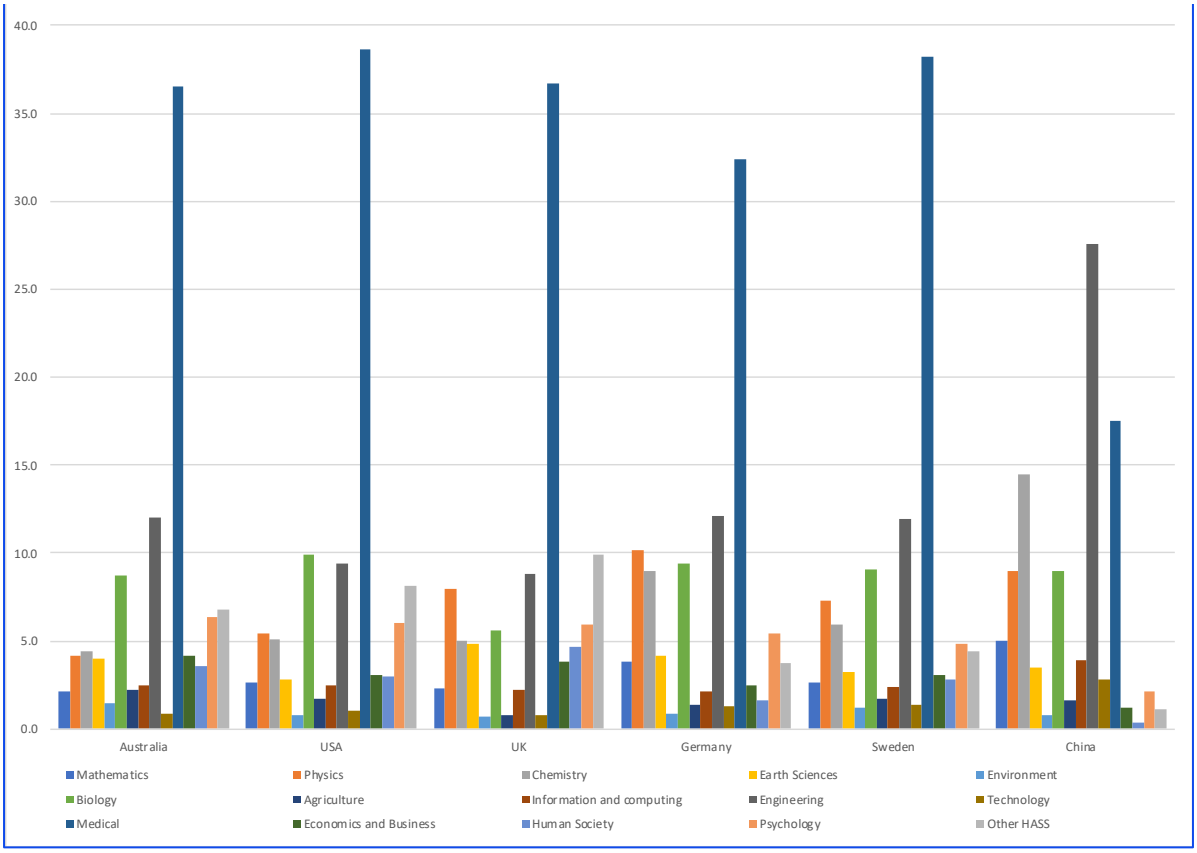


Table 11: International comparisons of research outputs classified by Fields of Research

	Australia	USA	UK	Germany	Sweden	China	Total WoS
STEM Fields							
Mathematics	2.1	2.6	2.3	3.8	2.6	5.0	3.4
Physics	4.2	5.4	8.0	10.2	7.3	9.0	6.1
Chemistry	4.4	5.1	5.0	9.0	5.9	14.5	8.2
Earth Sciences	4.0	2.8	4.8	4.2	3.2	3.5	2.7
Environment	1.5	0.8	0.7	0.9	1.2	0.8	0.8
Biology	8.7	9.9	5.6	9.4	9.1	9.0	8.6
Agriculture	2.2	1.7	0.8	1.4	1.7	1.6	1.9
Information & computing	2.5	2.5	2.2	2.1	2.4	3.9	2.7
Engineering	12.0	9.4	8.8	12.1	11.9	27.6	15.0
Technology	0.9	1.0	0.8	1.3	1.4	2.8	1.5
Medical	36.5	38.6	36.7	32.4	38.2	17.5	33.5
Total STEM	79.0	79.8	75.7	86.8	84.9	95.2	84.4
HASS							
Economics and Business	4.2	3.1	3.8	2.5	3.1	1.2	2.4
Human Society	3.6	3.0	4.7	1.6	2.8	0.4	2.3
Psychology	6.4	6.0	5.9	5.4	4.8	2.1	4.5
Other HASS	6.8	8.1	9.9	3.7	4.4	1.1	6.4
Total HASS	21.0	20.2	24.3	13.2	15.1	4.8	15.6
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Table 12: Increase in Research output 1999-2018 across Fields of Research

Name	Web of Science Documents 2019 (no)	Proportion 2019	Web of Science Documents 1999 (No)	Proportion 1999	Increase 1999-2018 (No.)	Proportion of Increase
01 Mathematical Sciences	3,147	2.2%	1,276	3.5%	1,871	1.8%
02 Physical Sciences	5,079	3.6%	2,036	5.6%	3,043	2.9%
03 Chemical Sciences	6,468	4.6%	2,131	5.8%	4,337	4.1%
04 Earth Sciences	4,372	3.1%	1,286	3.5%	3,086	2.9%
05 Environmental Sciences	4,537	3.2%	953	2.6%	3,584	3.4%
06 Biological Sciences	**11,709**	**8.3%**	**4,569**	**12.5%**	**7,140**	**6.8%**
07 Agriculture and Veterinary	3,472	2.5%	1,697	4.7%	1,775	1.7%
08 Information and Computing	**4,244**	**3.0%**	**794**	**2.2%**	**3,450**	**3.3%**
09 Engineering	**16,776**	**11.8%**	**3,377**	**9.3%**	**13,399**	**12.7%**
10 Technology	**2,420**	**1.7%**	**508**	**1.4%**	**1,912**	**1.8%**
11 Medical and Health Sciences	**42,939**	**30.3%**	**9,685**	**26.6%**	**33,254**	**31.6%**
12 Built Environment and Design	1,849	1.3%	152	0.4%	1,697	1.6%
13 Education	2,971	2.1%	396	1.1%	2,575	2.4%
14 Economics	2,235	1.6%	696	1.9%	1,539	1.5%
15 Commerce, Management, Tourism	3,698	2.6%	590	1.6%	3,108	3.0%
16 Studies In Human Society	5,163	3.6%	1,424	3.9%	3,739	3.6%
17 Psychology and Cognitive Sciences	9,456	6.7%	1,659	4.6%	7,797	7.4%
18 Law and Legal Studies	828	0.6%	106	0.3%	722	0.7%
19 Studies in Creative Arts, Writing	771	0.5%	187	0.5%	584	0.6%
20 Language, Communication Culture	1,838	1.3%	756	2.1%	1,082	1.0%
21 History and Archaeology	1,348	1.0%	766	2.1%	582	0.6%
22 Philosophy and Religious Studies	1,151	0.8%	416	1.1%	735	0.7%
Md Multidisciplinary	5,157	3.6%	971	2.7%	4,186	4.0%
	141,628	100.0%	36,431	100.0%	105,197	100.0%

Table 13: Australian Government R&D programs and activities valued at over $100 million in 2018-19 from 2009-10. Inflation Adjusted

Program/activity	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2009-10 %	2018-19 %
R&D Tax Incentive	1,912.2	1,931.7	3,020.4	2,968.8	2,824.5	2,844.0	2,935.7	2,688.0	2,684.2	2,194.6	21.2%	24.2%
Research Block Grants	1,454.9	1,516.0	1,598.0	1,626.3	1,665.7	1,747.2	1,829.9	1,714.5	1,841.6	1,825.2	16.1%	20.1%
NHMRC Research Grants	766.1	768.8	812.6	764.6	853.2	900.0	825.5	810.5	808.5	794.1	8.5%	8.8%
CSIRO	763.7	734.4	725.7	735.3	768.9	741.6	750.3	759.2	752.1	784.2	8.5%	8.6%
ARC - National Competitive Grants	701.6	717.1	798.7	875.0	872.8	848.7	815.3	717.8	718.4	721.0	7.8%	8.0%
Defence Science and Technology	441.6	429.9	451.4	434.9	420.6	437.6	503.5	431.5	447.2	420.4	4.9%	4.6%
Rural R&D Corporations	240.0	215.2	241.0	235.5	252.9	251.5	262.5	266.2	296.7	290.5	2.7%	3.2%
ANSTO	189.9	183.2	165.2	229.6	208.6	252.6	192.6	204.6	207.7	228.1	2.1%	2.5%
Australian Renewable Energy Agency	70.7	45.2	74.6	65.0	262.0	265.9	168.6	191.3	246.4	223.7	0.8%	2.5%
Medical Research Future Fund	-	-	-	-	-	-	-	17.3	135.8	209.2	-	2.3%
National Institutes Program - ANU	185.3	177.6	178.4	184.8	186.6	190.4	192.3	188.4	188.0	189.8	2.1%	2.1%
Geoscience Australia	141.5	118.5	111.5	113.4	129.6	126.2	121.3	137.5	143.2	173.4	1.6%	1.9%
CRCs	193.8	176.0	165.6	156.0	145.3	149.1	141.0	144.2	152.4	157.4	2.1%	1.7%
NCRIS	112.8	109.2	-	-	79.2	99.6	150.0	144.6	399.2	152.8	1.3%	1.7%
ACIAR	78.9	90.0	97.6	104.9	98.0	100.6	94.1	99.8	102.1	100.9	0.9%	1.1%
Australian Antarctic Division	126.6	103.6	103.2	102.0	103.2	94.3	93.9	104.6	100.1	99.4	1.4%	1.1%
All other programs	1,636.7	1,725.8	1,558.3	1,220.1	937.6	794.0	661.4	686.7	675.5	502.0	18.2%	5.5%
Total	9,016.4	9,042.1	10,102.2	9,816.1	9,808.8	9,843.2	9,737.8	9,306.9	9,899.2	9,066.7	100.0%	100.0%

Source: Commonwealth of Australia, Science, *Research and Innovation Budget Tables, 2018-19*. Inflation adjusted by applying the GDP deflator, included in the Table documentation.

Attachment 3: Policy evolution of Australian Industry and Innovation Policy

The evolution of industry and innovation policy since the Second World War followed a number of phases.

Time frame	Phase
1. 1942-1948	Industrialisation – developing a manufacturing sector
2. 1948-67	The Long Boom: Industry Protection and Agrarian Socialism
3. 1967-73	Ending the "Mixed Economy"
4. 1975-1983	The Fraser years
5. 1983-1987	Restructuring
6. 1991-1996	Competition and Competitiveness: Microeconomic reform
7. 1996-2007	From industry policy to innovation policy
8. 2007-2013	Rekindling industry policy
9. 2013-2015	Return to the market
10. 2015-2016	Innovation reboot
11. 2016 –2018	Re-integrating innovation into industry strategy
12. 2018 and beyond	Policy Reset

Comments on each phase follow.

1. Industrialisation – developing a manufacturing sector

World War II had a great profound impact on the Australian economy and permanently changed how the economy operated. Prior to 1939, the Commonwealth Government had little role in the management of the Australian economy. The state governments levied most of the income tax, and Australia's international trade was dictated by its relationship with the British Empire.

The 1945 White Paper: *Full Employment in Australia* (Australia., 1945) set out an agenda for post-war growth, strongly supported measures for readjustment in manufacturing from a wartime to a peacetime footing. A major focus was on renewal of capital equipment, manpower planning and training, and opportunities in exports and new markets.

The economic policies of the Labor government stimulated the economy by increasing production and ending unemployment. A wide range of industries, including motor vehicles, metal processing, TCF (textiles, clothing and footwear) and chemicals all benefitted from government contracts and regulations, tariff protection, and import controls. The Government policy stance meant that the government would maintain control over certain segments of the economy to continue economic growth, restrain inflation and institute full employment.

Post-war economic reconstruction was also underwritten by a decisive policy of national development - in line with the general socialist ideals that the ALP held and were then widely supported within the broader labour movement. A number of Australian companies such as QANTAS were nationalised in this period, while a range of government run enterprises such as TAA and the ANL were set up to expand the government sector. In 1948 the Snowy Mountain River Project was commenced.

This immediate post war policy achieved high economic growth, but led to growing political opposition, especially after the failure of the government to nationalise the banking sector in 1948. Political opponents also capitalized on the retention of rationing of food and petrol. As a result, in 1949 the government was replaced at national elections with a more conservative government committed to supporting a *mixed economy*.

2. 1948-67 - the Long Boom: Industry Protection and Agrarian Socialism

The Menzies government continued to closely regulate economic activity. More encouragement was given to private industry, but where public enterprise was deemed "necessary" it was retained, and in some cases expanded.

A growth commitment continued with the Department of National Development which operated until 1972. The Department was expected to plan for the supply of basic commodities, promote decentralisation and regional development, undertake surveys of natural resources, and plan for the development of primary and manufacturing industries and the stimulation of housing construction – principally through the Commonwealth-State Housing Agreement. The Department did not function as an 'economic development powerhouse'. It was a Country/National Party Portfolio.

The Tariff Board, established in 1920, had responsibility for advising on the post-war conversion of Australian industries. It did not do this well.

During the 1960s an increase in tariff protection for new industries protected jobs and profits, but lowered the need for productivity and innovation, and by 1966 foreign investment was shifting to the less heavily regulated mining and pastoral sectors.

Charles Massey, in *Breaking the Sheep's Back* (Massy, 2011), observes:

> By 1967-68, on the calculation of the Tariff Board itself, Australian manufacturers were cosseted behind a massive tariff wall worth $2700 million a year. To put this huge protection cost in context, the $2.7 billion tariff bill was 20% higher than the total annual expenditure by all Australian governments (federal, state, local) on education, health, social security, welfare and defence. The huge tariff burden equated to an average effective tariff for manufacturers of 46%, with some firms receiving 120% protection (Massy, 2011) p.52

The failure to gradually remove protection would have lasting consequences. The strategy of providing *assistance* for industry to grow and prosper, as envisaged in the 1945 *White Paper*, eventually came to be seen as an *entitlement*, on the part of industries that failed to adjust, that should be preserved in an unreconstructed state. The protected manufacturing industry lobby became quite powerful using weapons of job creation and strategic significance.

But the job creation rationale largely failed as large factory based manufacturing enterprises became uneconomic and unviable in a globally competitive environment. Strategic significance is important for industries that have committed to adjustment and modernisation.

3. 1967-73 - Ending the "Mixed Economy"

After 1967 the favourable conditions that Australia had enjoyed in the international economy began to change. From 1962 Britain progressively abandoned the system of Imperial Preference adopted in 1932 and move towards membership of the European Economic Community. Australia's privileged access to the British market ended in 1965. The UK did not provide any adjustment assistance.

In the era of the Vietnam War the rate of U.S. investment into Australia began to decline and Australia began to face greater economic competition and a steady decline in its terms of trade. The governments that followed the Menzies in the period 1966–1972 increasingly found they had to manage the rising expectations of consumers and industry in the 'developing nation' ideal of the 'mixed economy'.

In the period 1972–1973 Australia began to experience the beginnings of "stagflation" as unemployment and inflation began to rise simultaneously for the first time. In 1973, with Australia experiencing sharply rising inflation, Fred Gruen, special consultant to the Whitlam Government, proposed a 25% across the board tariff cut, which was adopted by the government. The 1973 oil crisis had caused prices to spike and, according to government figures, inflation topped 13% for the year 1973-1974.

The rapid change in economic conditions in 1972-73 was not countered by a change in government policy. Whitlam's desire to increase the wages and conditions of the federal public service fed into a 30% increase in imports and a $1.5 billion increase in the trade deficit by the end of 1974.

Primary producers of commodities such as beef were caught in a credit squeeze as short-term interest rates rose to extremely high levels. Unemployment also rose significantly despite continuing government spending.

4. The Fraser years 1975-1983

The Fraser government, elected in 1975, promised greater control of government spending, and an end to inflationary pay increases in the public sector. But its close links with industry and commerce made it reluctant to institute deep seated economic reform. The Fraser Government preferred to promote policies similar to those adopted in the earlier post-war period; chiefly wage and credit restraint, and tighter government economic regulation of the economy.

In 1982 the Government dismissed the findings of the Campbell Commission into Banking which had had recommended deregulation of the banking industry (Australia. Committee of Inquiry into the Australian Financial System, 1981).

For most of the Fraser Government's time in office the Industry Assistance Commission came under the responsibility of the Minister for Business and Consumer Affairs. In 1983 responsibility passed to the Minister for Industry and Commerce (John Button) and from 1987 onwards responsibility has been held by the Treasurer. This reflects the broader economic remit of the Commission – rather than a vehicle for manufacturing industry assistance.

5. Restructuring 1983-1987

In the early 1980s, large parts of Australian manufacturing were recognised as seriously lacking in international competitiveness and in urgent need of restructuring to promote innovation, modernisation and efficiency. By 1983, with the change in Government, Australian manufacturing industry was still focused on the domestic market. However, factories were closing, and people were not prepared to think much about longer term solutions. There was an absence of an export culture.

Over the ensuing five years a series of initiatives were taken to open up the Australian economy to greater international competition with the main steps being on the macro-economic front with the floating of the exchange rate, deregulation of the banking sector, and controls on capital movements.

The approach to industry policy was based on the implementation of a series of industry restructuring plans for the main industries facing difficulties with foreign competition, namely the PMV, TCF, heavy engineering, steel, and shipbuilding industries. The plans were designed to be temporary and to inject generous positive assistance to help these industries to modernise, innovate and find new markets and at the same time to wind down the high levels of protection on most of their products.

The basis of the assistance packages was a view that Australia industry had been so heavily protected that it was not up to the task of competition. However, many businesses failed to adjust and continued to advocate for protection and subsidy. It became a self-defeating strategy.

In 1988, the Government introduced an across-the-board program to phase down all tariffs (except for PMV and for TCF which had their own tariff reduction programs) to either 10% or 15% by 1992.

The general tariff reduction program was extended in 1991 as a key plank in the policy initiative *Building a Competitive Australia*. This is the starting point for a more detailed analysis of a *25 Years of Reviews: the Evolution of Australian innovation and Industry Policy* that begins in the next section.

6. 1991-1996: Competition and Competitiveness: Microeconomic reform

The Hawke Government's *Competitive Australia Statement* (Australia. Department of the Prime Minister and Cabinet, 1991) drove the micro-economic reform agenda for the next five years.

This early period saw some significant research and policy insights including *Managing the Innovating Enterprise* (Carnegie et al., 1993) and research projects supported by the former Bureau of Industry Economics (Australia. Bureau of Industry Economics, 1995, Australia. Bureau of Industry Economics, 1996).

One Nation announced an Australian Government program of infrastructure development to be carried out under the Keating Government from 1991 to 1996 (Australia. Prime Minister, 1992). Much of the program was implemented as a means of stimulating the economy in the aftermath of the early 1990s recession. The major infrastructure projects announced in *One Nation* provided the foundation for future development.

The *National Competition Policy Review*, Hilmer, 1993, recognised that Australia, for all practical purposes, was a single integrated market, increasingly exposed to domestic and international competition. The subsequent national competition policy aimed to promote and maintain competitive forces to increase efficiency and community welfare, while recognising other social goals.

The 1994 *Working Nation* White Paper describes the Commonwealth Government's plan for achieving economic growth, and increasing employment opportunities for urban, rural and regional Australia (Keating, 1994). Specific policy initiatives included:

- Training and education reforms to broaden and deepen the skills base and equip young people for work in the modern Australian economy.
- A strategy to help the regions of Australia more effectively share in the nation's prosperity and contribute to the national effort.
- Microeconomic reforms and an industry policy to remove impediments to competition and create an environment that will enable firms to perform at their best and assist them to develop international markets.

In 1995 the Karpin Report, *Enterprising Nation: Renewing Australia's Managers to Meet the Challenges of the Asia Pacific Century*, was released (Karpin, 1995).

Special attention was given to the need for an enterprise culture, small business, globalisation, diversity, lifelong learning and enterprise and education institution best practice. The Taskforce identified its approach in the following terms:

> The general philosophy of the Task Force has been to find pathways to lasting change and improvement through seeking enterprise and individual-driven solutions to the problems and challenges facing Australia's business leaders, managers, educators, trainers and government policy makers.

The Chairman of the Task Force asserts in his introduction that permanency of reform and constructive change will depend on recognition that excellent leaders and managers require well structured, systematic education and continual development, so that they can add maximum value to the national economy through their performance within the enterprise

Much of the material covered in the Report remains relevant to this day.

7. 1996-2007: From industry policy to innovation policy

The Howard Government, elected in 1996, had a concern that micro-economic reform strategies weren't delivering enough in terms of productivity and employment growth. However, the Government and its advisers saw industry policy as "picking winners". Innovation policy offered a way in to sustaining an interest in economic development and growth.

Coincidentally, during the early 1990s economists became increasingly aware of the crucial role that technology plays in economic growth and sought to incorporate it into growth models. This gave rise firstly to 'new growth theory' or 'endogenous growth theory'. Technology was modelled as an *internal* outcome of R&D investment and investment in human capital (talent formation). Technology and human capital were considered to exhibit increasing returns to scale, as the engine of growth.

New growth theory provided an argument for government investment in Research and Development, but not necessarily defining a specific strategy. That is, new ideas were endogenous to a firm, rather than from external organisations that could transform ideas into products (exogenous growth). However, the increasing emphasis on relationships between technical change and growth encouraged policymakers to continue investing in public R&D, developing business R&D support programs, and investing in education and training to foster growth (Mazzucato, 2015).

The 1990s saw the development and implementation of innovation led growth policies to support the knowledge economy – a term used to denote the greater importance of investing in knowledge creation to promote economic competitiveness.

Australian governments were keen to explore the developmental view of innovation but have been unwilling to fully embrace it, or commit to it over the longer term. State Governments, particularly Victoria (STI Initiative) and Queensland (Smart State and Advance Queensland initiatives) were far more engaged.

From 1997 there was outpouring of policy papers from industry organisations and think tanks, including an influential Australian Business Foundation paper advocating a shift in policy direction, *The High Road or the Low Road: A Report on Australia's Industrial Structure* (Marceau et al., 1997) and *Make or Break: 7 Steps to Make Australia Rich Again* (Economist

Intelligence Unit, 1997). This followed a series of reports and papers prepared by the Australian Science and Technology Council (ASTEC, 1996b, ASTEC, 1996a).

Over next 10 years Australian governments took policy initiatives, based on inquiries and reviews, aimed at strengthening the innovation system. But most areas of review activity and policy initiatives were in specific policy domains, rather than looking at ways of strengthening the innovation *system.* It was a process of experimentation, learning, and adaptation. There were regular changes in direction with changes in governments and Ministers.

The *Commission of Audit*, appointed by the incoming Howard Government in 1996, laid out principles for "market based" economic development. It stimulated a program of privatisation, outsourcing, contracting. It also advocated the "devolution" of programs to the States and Territories, such as business assistance and support programs(National Commission of Audit and Offficer, 1996). This approach largely precluded active industry policy.

The Mortimer Report, *Going for Growth: Business Programs for Investment, Innovation and Export 1997,* was an early Howard Government Report embracing the new innovation and industry policy thinking (Australia. Review of Business Programs, 1997). It made several recommendations for Government to:

- Adopt a target per capita income growth of 3.4% per annum to be achieved through increasing national savings and investment, maintaining low inflation and microeconomic reform.
- Develop 'action agendas' in priority areas to be jointly formulated by industry leaders and government using 'Supermarket to Asia'[37] as a model. Supermarket to Asia aimed to improve access to Asian markets and cut costs of exporting.
- Consolidate business support programs into *five key programs, from the roughly 70* that Mortimer looked at, with guaranteed five-year funding arrangements.

In many ways this Report set an economic and industry agenda for the next decade

8. 2007-2013: Rekindling industry policy

The election of the Rudd Government in 2007 saw a rekindling of interest in innovation and industry policy, and particularly manufacturing policy. *Building innovative capability: Review of the Australian Textile, Clothing and Footwear (TCF) Industries, 2008* (Green, 2008). The Review included a comprehensive discussion of the changing role of industry policy and articulation of a rationale for industry policy:

> Industry policy involves interventions: first, to affect the industrial structure of an economy, i.e. the share of different industries within an economy; and, second, to improve the performance of firms and clusters of firms within and across these industries. This performance is influenced by factors such as the removal of barriers to product and process innovation. In turn, this reflects the technological 'absorptive capacity' of firms and the supporting educational, training and research institutions; access to efficient capital markets; access to cost-effective information regarding suppliers and markets, and implementation of work-organisation systems that encourage quality and continual improvement. The goals of industry policy typically include employment growth, per capita income growth, technological advancement, defence, correcting trade imbalances, equity, and community cohesion.

The Review also included an extended critique of economic growth models and, in particular their contribution to understanding of innovation. It is, of course a disappointment that these arguments had to be repeated after they had been well canvased ten years earlier. This no doubt reflected a confused understanding of the reality of innovation among policy makers in the conservative economic portfolios.

Management Matters in Australia: Just How Productive Are We? (Green 2009) reviews management practices in Australian manufacturing firms and the link between these practices and the productivity performance of firms. The study found that while Australian management practices are not in the top rank of performance worldwide, they are also not among the worst. They currently rate as only moderately above average when benchmarked globally, leaving significant scope for consistent and sustained improvement across key areas.

[37] Supermarket to Asia was superseded by the National Food Industry Strategy Limited.

The research shows that the quality of management practices has a measurable impact on labour productivity, as well as sales and the number of employees in firms. The study also found that there is considerable variance in management practices within Australian firms.

Building Defence Industry Capability: A Policy for a Smarter and More Agile Defence Industry Base, 2010 was prepared following an extensive submission and consultation process (Australian Government. Department of Defence, 2010). It includes policy proposals to:

- Build skills, innovation and productivity
- Establish a PIC Innovation Program
- Establishment of a Defence Industry Centre
- Establish a Defence Industry Innovation Board

The Statement mentions innovation 128 times.

The *Smarter Manufacturing for a Smarter Australia: Report of the non-Government members of the Prime Minister's Taskforce on Manufacturing,* was released in 2012. In the Executive Summary, the non-Government members advise –

> … Australia's future will be brighter with a broad-based national economy, built on more than a few industries in more than a few regions. A broad based national economy is one that is stronger, more resilient, more innovative and ultimately more able to provide for the needs of Australia and Australians.
>
> It is how we can break the cycle after the 'lost decade' in which apparent prosperity has boomed, while underlying productivity growth has stalled and competitiveness gone backwards. This is particularly important right now because Australia's current development path exposes the country to an increasing reliance on commodity exports. (Australia. Prime Minister's Manufacturing Taskforce, 2012)

Many, but my no means all of the policy directions have been taken up in different contexts over the ensuing six years.

The *National Food Plan: Our Food Future*, launched by Senator the Hon. Joe Ludwig, in 2013, celebrates Australia as having a strong, safe and stable food system and high levels of food security. "Every year Australian farmers and fishers produce enough food to feed around 60 million people—far more food than we consume. Australia exports over half of the food it produces yet over 90% of fresh produce sold here is also produced here" (Department of Agriculture Fisheries and Forestry, 2013).

> Most Australians can afford to buy the food they need and can access safe and nutritious food. Our enormous range of growing conditions means that we can produce a huge variety of food and have the wealth to import food when we need or want it. We can always do better, but overall Australia is fortunate when it comes to food.
>
> But the world is changing. In the years ahead Australia's food system will face challenges, such as climate change, population growth, changing economic conditions, competition for resources and diet-related health issues. Along with the challenges there will be unprecedented opportunities for Australia's food industry.

Meeting the challenges and seizing the opportunities will create enormous social, economic and environmental benefits for Australia. To harvest the opportunities of the future we need to focus on four priority areas – *competition, safety, research, sustainability*.

A Plan for Australian Jobs: The Australian Government's Industry and Innovation Statement, 2013 (Australia. Department of Industry Innovation Science Research and Tertiary Education, 2013) responds to the report, *Smarter Manufacturing for a Smarter Australia*, by the non-Government members of the Prime Minister's Taskforce on Manufacturing. It included new policy measures to address the concerns of the sector, including 'the current period of intense structural change'.

> The fundamental issues for manufacturing — to innovate and to improve productivity to capture the opportunities of the future — are also important for businesses and jobs across Australia's entire economy. The policies in *A Plan for Australian Jobs* will ensure Australia has a dynamic, diverse and globally connected economy, across a range of industries and regions. These new initiatives reflect the strategy laid out in the Australia in the Asian Century White Paper in which the Government set out its long-term plan to deliver a prosperous and resilient Australia by 2025, achieving growth in income and jobs by lifting national productivity.

The Plan notes that the rise of Asia will be a defining feature of Australia's future in that in coming years, Asia will not only be the world's largest producer, but also its largest consumer. As the populations of Asia's economies become more affluent they will demand a range of

quality goods and services — from the dinner table to health care, education and the family holiday.

This is seen to present Australia with great opportunities not only for our manufacturing industry but also for our services sector. We are in the right place at the right time. The Government's policies to improve productivity and competitiveness are positioning Australia in the race to the top, not to the bottom.

The Plan states that to realise these opportunities we will need innovative and dynamic businesses capable of connecting to global and Asian supply chains. Working with industry, unions, educators and the research sector, the Government.

9. 2013-2015: Return to the market

The election of the Abbott Government in 2013 represented a pushback for innovation and industry policy. A Commission of Audit was announced by the Treasurer, the Hon Joe Hockey MP, and the Minister for Finance, Senator the Hon Mathias Cormann, on 22 October 2013. The Commission was constituted by the Chair of the Business Council of Australia, a former Secretary to the Treasury, a former Secretary to the Department of Finance, and former Minister (Hon. Amada Vanstone.

The report of the Commission heralded a period of fiscal austerity around a conservative economic agenda. It amounted to a rejection of an innovation systems and development approach to innovation and industry and a recommitment to market mechanisms. The term innovation was effectively banned from the policy and public service lexicon.

The period saw a strong focus on science on the basis of conservative economics understanding of the role of science and technology on economic growth. This understanding continues, with a focus on education in Science, Technology and Mathematics (STEM) and interest in the results and impact of investments in science. It was the beginning of a trend reduction in resources for science and an expectation that more would be committed to applied and 'useful' research

The Commission made a number of recommendations along the lines to make industry rely less on industry assistance, and more on commercial discipline to reduce costs and improve quality to better meet customer demands. Not all recommendations were implemented, but the Commission of Audit exercise set the scene for industry and innovation policy for the next two years.

The *Industry Innovation and Competitiveness Agenda: An action plan for a stronger Australia*, was released in 2014. In the Forward to the Agenda (Australia. Minister for Industry and Science, 2014) the Prime Minister wrote:

> Improving Australia's competitiveness is a central part of the Government's Economic Action Strategy to build a strong, prosperous economy and a safe, secure Australia.
>
> We've already scrapped the carbon tax and mining tax; removed more than 10,000 pieces of unnecessary legislation and regulations; established one-stop shops for environmental approvals; commenced the largest infrastructure construction programme in Australian history; and signed free trade agreements with Japan and Korea.
>
> This is just the start—because job creation, growth and competitiveness need constant attention.

The Agenda was said to draw on the insights of the Prime Minister's Business Advisory Council and other experts.

The *Productivity Commission: Australia's Automotive Manufacturing Industry, 2014* provided the basis for reducing public subsidies for the motor vehicle industry since the Button Plans of the 1980s. The Commission Report included the following (Australia. Productivity Commission, 2014):

- Decades of transitional assistance to automotive manufacturing firms ($30 billion between 1997 and 2012) has forestalled, but not prevented, the significant structural adjustment now facing the industry.
- The policy rationales for industry-specific assistance to automotive manufacturing firms are weak and the economywide costs of such assistance outweigh the benefits.
- The Automotive Transformation Scheme should be closed after Ford, Holden and Toyota have ceased manufacturing motor vehicles in Australia.

All three of the major motor vehicle assemblers had withdrawn from Australia by 2015. A significant aftermarket remains, however.

A different perspective was provided in the Paper *Compete to Prosper,* the result of a research effort conducted by McKinsey Australia (Lydon et al., 2014). The Executive Summary of the Report set a scenario in the following terms:

> Australia has enjoyed a prolonged period of economic growth, which has created jobs, raised living standards and funded social services.
>
> Continued success is very far from assured. A new question for Australia's leaders has become all too real and urgent: How to transition to new sources of growth as commodity prices and investments in resources projects normalise.
>
> And there is no escaping that Australian firms are competing in an increasingly globalised economy. Moreover, fundamental changes to supply and demand are reshaping how the economy operates, down to the level of individual jobs.
>
> On the demand side, the rapid and continuing growth of emerging economies, including China, India and Indonesia, has been much discussed in Australia. The global consuming class is expected to grow from 2.4 billion to 4.2 billion people in 2025, and will be around 150 times Australia's expected domestic population.
>
> There are remarkable opportunities for Australian firms to export goods and services to meet the needs of this global market, particularly Asian consumers. But Australia enjoys no guarantee of success. Growth will not come to Australia; Australia must go for growth. And the time to act is now. Other countries are moving and the window of opportunity will not remain open indefinitely.
>
> On the supply side, disruptive technologies will reshape industries and economies.

The Report's recommendations canvassed -

1. Raising competitiveness is job number one for Australia's long-term prosperity
2. Focus on the sectors and tasks where Australia can win
3. Improving the competitiveness of individual sectors
4. Taking a purposeful approach to raise Australia's global competitiveness

These are themes seen in many subsequent McKinsey Reports and input to government innovation and industry policy papers.

The Prime Minister and the Minister for Small Business announced a *Review of Competition Policy* (Harper Review) in December 2013. The Report was released on 31 March 2015[38]. The Government responded that it would implement most the Review's recommendations. The Government commented in its response[39]:

- Technological change has brought new opportunities and challenges. One of the most innovative is the 'sharing economy', facilitating new entrepreneurial activity and creativity in service delivery.
- At the same time the population is ageing, requiring innovative approaches to the delivery of high-quality human services.
- To respond to these challenges, we need a competition framework that is fit for purpose.

10. 2015-2016: Innovation reboot

The *National Innovation and Science Agenda (NISA)*, 2015 focussed on four key pillars:

- Culture and capital
- Collaboration
- Talent and skills
- Government as an exemplar

Together these pillars provided a framework for Australian innovation policy for the next two years. The initiatives were worth $1.1 billion over *four* years.

The *Industry Growth Centres Initiative,* announced in 2015, was aimed at enabling businesses with "winning strategies to self-select and grow, by removing impediments and unlocking potential at the industry level". The Centres would encourage organisations to work closely together to unlock commercial opportunities and reduce risk, and to form commercial research and development partnerships with each other, and with the research sector.

[38] http://competitionpolicyreview.gov.au/final-report/
[39] http://www.treasury.gov.au/PublicationsAndMedia/Publications/2015/CPR-response

Six Centres were established: food and agribusiness; mining equipment, technology and services; oil, gas and energy resources; medical technologies and pharmaceuticals; advanced manufacturing; and cybersecurity. The Centres are expected to address sector-wide impediments to productivity and competitiveness by:

- developing and implementing a roadmap of priority actions to lift the competitiveness of the sector and inform Centre activities;
- taking practical steps with governments to improve the regulatory environment;
- facilitating new commercial partnerships through supporting industry-led projects between SMEs and large businesses, and with the research sector, to develop innovative products and services;
- enhancing businesses' ability to enter global value chains and improving workforce skills, building on the services available through the Entrepreneurs Infrastructure Programme; and
- developing annual industry knowledge priorities to inform the research sector of industry needs and commercialisation opportunities.

The *Agricultural Competitiveness White Paper: Stronger Farmers Stronger Economy*, Minister for Agriculture 2015, set a vision to "build a more profitable, more resilient and more sustainable agriculture sector to help drive a stronger Australian economy". It identified five key priorities including:

- A smarter approach to farming based on a strong research and development system that underpins future productivity growth; and effective natural resource policy that achieves a cleaner environment as part of a stronger Australia.
- Access to premium markets through the availability of a large number of premium export markets open to our produce and a strong biosecurity system that maintains our favourable plant and animal health status.

The White Paper identified the following Rural RD&E Priorities:

- advanced technology, to enhance innovation of products, processes and practices across the food and fibre supply chains through technologies such as robotics, digitisation, big data, genetics and precision agriculture;
- biosecurity, to improve understanding and evidence of pest and disease pathways to help direct biosecurity resources to their best uses, minimising biosecurity threats and improving market access for primary producers;
- soil, water and managing natural resources, to manage soil health, improve water use efficiency and certainty of supply, sustainably develop new production areas and improve resilience to climate events and impacts; and
- adoption of R&D, focusing on flexible delivery of extension services that meet primary producers' needs and recognising the growing role of private service delivery.

The Rural RD&E Priorities focus R,D&E investment in areas of greatest need and are particularly important in guiding the rural research and development corporations and thus impact significantly on the work of research providers and other research investors in related fields.

11. 2016 –2018: Re-integrating innovation into industry strategy

The problem with an innovation systems approach to policy is that they do not produce objectives. This is convenient if the approach is to avoid "picking winners". While the Government as a whole does not pick winners, a new *sectoral approach* to innovation and industrial policy is emerging.

For example, the *Defence Industry Policy Statement, 2016*, sets out a greater role for defence in industry and innovation policy. It is structured in four parts:

1. Delivering Defence capability. A more focused, coordinated and transparent relationship between Defence and industry is required to maximise delivery of Defence capability.
2. A new approach to Defence innovation. Defence will transform the way it approaches innovation, streamlining its engagement with industry and academia, simplifying access to Defence research funding, and creating a seamless link between capability needs, smart ideas and innovation in Australian industry.
3. Driving competitiveness and export potential. The Government will maximise opportunities for competitive Australian businesses, building export potential, depth of skills and diversification for the Australian defence industry.
4. Cutting red tape. The Government will streamline tendering and contracting procedures, and rationalise the industry programs to cut red tape and make it simpler and less costly for

Australian industry to support Defence, aligned with implementation of the *First Principles Review: Creating One Defence*[40].

Released in 2017, Australia 2030: Prosperity through Innovation (Innovation and Science Australia, 2017) plans for a society and economy that all Australians can aspire to by 2030. The Plan makes 30 recommendations that underpin five strategic policy imperatives:

- Education: respond to the changing nature of work by equipping all Australians with skills relevant to 2030
- Industry: ensure Australia's ongoing prosperity by stimulating high-growth firms and raising productivity
- Government: become a catalyst for innovation and be recognised as a global leader in innovative service delivery
- Research and development (R&D): improve R&D effectiveness by increasing translation and commercialisation of research
- Culture and ambition: enhance the national culture of innovation by launching ambitious National Missions

ISA consulted with stakeholders across the Australian innovation, science and research system throughout 2017 and received 130 public submissions.

The Government's response to the Strategy has been, at best, lukewarm. In addition to Defence, sectoral policies have been developed in the rural sector – driven by string advocacy from farmer organisations. The main focus of Commonwealth industry and innovation policy is around the Growth Centres (six sectors). There has been some advocacy for Growth Centres to be a delivery vehicle for a range of business support programs.

State and Territory Governments have been very active in developing industry sectoral policies. Several states have defence strategies, and one has a Minister for Defence.

12. Policy Reset: 2018 and beyond

This period is characterised by the absence of any policy leadership for national innovation and industrial strategy. Government has reduced its commitment of resources and gives little priority to innovation. There are hundreds of disconnected small grants across multiple portfolios without any overarching vision of commitment. There is some faith in the role of Industry Growth Centres – as a 'beacon' for innovation and industrial strategy, but they are poorly resourced.

40 http://www.defence.gov.au/whitepaper/Docs/2016-Defence-Industry-Policy-Statement.pdf

Attachment 5: Expenditure on R&D Programs 1989-90 – 2019-20

Program / Activity	Total Expenditure 1989-90 to 2019-20	Number of Years Operating	Average Program Expenditure Per Annuum	First year	Last year
00. Multiple categories					
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	21,884.2	42	521.1	1978-79	2019-20
Australian Nuclear Science & Technology Organisation (ANSTO)	5,146.0	42	122.5	1978-79	2019-20
Geoscience Australia	3,470.4	42	82.6	1978-79	2019-20
Australian Institute of Marine Science (AIMS)	879.6	42	20.9	1978-79	2019-20
Bureau of Meteorology Research Activities	433.2	41	10.6	1979-80	2019-20
R&D Tax Concession (125%)	13,206.0	29	455.4	1985-86	2013-14
Australian Institute of Aboriginal and Torres Strait Islander Studies (AIATSIS)	48.3	21	2.3	1999-00	2019-20
Australian Research Council (ARC) - National Competitive Grants Program	12,580.9	20	629.0	2000-01	2019-20
R&D Refundable Tax Offset	1,728.0	16	108.0	2001-02	2016-17
National Collaborative Research Infrastructure Strategy	1,770.1	17	104.1	2005-06	2019-20
Premium Tax Concession for Additional R&D (175%)	2,730.0	12	227.5	2001-02	2012-13
R&D Tax Incentives - Refundable	16,523.0	9	1,835.9	2011-12	2019-20
R&D Tax Incentives - Non Refundable	6,800.0	9	755.6	2011-12	2019-20
R&D Tax Concession - Interim Transition Measure	110.0	2	55.0	2009-10	2010-11
Total	87,309.7	42	2,078.8		
Inflation Adjusted	115,112.5	42	2,740.8		
01. Exploration and exploitation of the Earth					
Australian Antarctic Division	3,068.5	42	73.1	1978-79	2019-20
Land and Water Research	273.9	31	8.8	1979-80	2009-10
Australian Climate Change Science program (ACCSP)	87.4	12	7.3	2004-05	2015-16
Office of Water Science	108.2	7	15.5	2011-12	2017-18
Urban Water Centres of Excellence program	40.0	6	6.7	2008-09	2013-14
Super Science - Marine and Climate	357.0	5	71.4	2008-09	2012-13
Bilateral Climate Change Partnerships program	9.1	5	1.8	2004-05	2008-09
AuScope Australian Geophysical Observing System	23.0	4	5.8	2010-11	2013-14
Indian Ocean Marine Research Centre	34.0	4	8.5	2010-11	2013-14
Combined geological and bioregional Assessments	24.0	3	8.0	2017-18	2019-20
Groundwater Infrastructure Research Operational Support	0.5	2	0.2	2012-13	2013-14
Integrated Marine Observing System	7.2	2	3.6	2012-13	2013-14
National Sea Simulator	1.5	2	0.7	2012-13	2013-14
Structure and Evolution of the Australian Continent	4.0	2	2.0	2012-13	2013-14
Centre for Climate Change and Energy Research	40.0	1	40.0	2009-10	2009-10
Institute for Marine and Antarctic Studies	45.0	1	45.0	2009-10	2009-10
Antarctic Science Collaboration Initiative	5.0	1	5.0	2019-20	2019-20
Total	4,128.4	42	98.3		
Inflation Adjusted	6,008.5	42	143.1		
02. Environment					
Supervising Scientist	343.7	42	8.2	1978-79	2019-20
Great Barrier Reef Marine Park Authority (GBRMPA)	96.8	29	3.3	1991-92	2019-20
Greenhouse Research (NGRP)	72.0	16	4.5	1988-89	2003-04
Marine and Biodiversity Research	63.6	11	5.8	2004-05	2014-15
National Carbon Accounting System	27.2	8	3.4	1998-99	2008-09
National Environmental Research Program	180.1	10	18.0	2005-06	2014-15
Water Resource Assessment and Research	1.8	10	0.2	2007-08	2016-17
Parks Australia (Commonwealth marine)	1.4	4	0.4	2012-13	2019-20
Greenhouse Gas Abatement program	115.0	8	14.4	2001-02	2008-09
International Whaling Commission Southern Ocean Research Partnership	13.1	8	1.6	2008-09	2015-16
Environmental Water Knowledge and Research	11.9	7	1.7	2013-14	2019-20
National Environmental Science Programme (NESP)	136.7	6	22.8	2014-15	2019-20
National Landcare Programme - Natural Heritage Trust	15.8	5	3.2	2014-15	2019-20
Caring for our Country - Natural Heritage Trust	12.1	6	2.0	2008-09	2013-14
Carbon Farming Futures - Methodology Development	3.5	7	0.5	2011-12	2015-16
Conservation and Preservation Program	1.8	5	0.4	2009-10	2013-14
Emissions Measurement and Analysis	33.5	5	6.7	2004-05	2008-09
Indigenous Carbon Farming Fund	1.9	4	0.5	2012-13	2016-17
Low Emissions Technology and Abatement	14.4	5	2.9	2004-05	2008-09
National Marine Science Centre	12.1	4	3.0	1999-00	2002-03
Great Barrier Reef Foundation - contribution	12.5	4	3.1	2013-14	2016-17
National Carbon Accounting Toolbox	12.2	4	3.1	2009-10	2012-13
National Oceans Office	9.4	4	2.4	2001-02	2004-05
Natural Resource Management Planning for Climate Change	13.6	4	3.4	2012-13	2015-16
Building the Sydney Institute of Marine Science	19.5	3	6.5	2009-10	2011-12
Reef Trust	105.0	3	35.0	2016-17	2018-19
Atlas of Living Australia	2.8	2	1.4	2012-13	2013-14
Terrestrial Ecosystems Research Network	3.1	2	1.5	2012-13	2013-14
Geological and Bioregional Assessments	11.6	2	5.8	2018-19	2019-20
International Blue Carbon Stocktake	0.1	1	0.1	2016-17	2016-17
Future environmental science program (NESP successor program)	0.0	0		#N/A	
Total	1,348.0	42	32.1		
Inflation Adjusted	1,754.0	42	41.8		
03. Space					
Australian Astronomical Observatory (AAO)	192.0	40	4.8	1978-79	2017-18
National Space Programme	39.8	10	4.0	1985-86	1998-99
Square Kilometre Array Radio Telescope Project	102.9	9	11.4	2011-12	2019-20
Giant Magellan Telescope	103.3	6	17.2	2009-10	2014-15
Super Science - Space Science and Astronomy	90.0	4	22.5	2009-10	2012-13
Australian Space Science Program	43.3	4	10.8	2009-10	2012-13
Mount Stromlo Observatory Reconstruction	7.3	1	7.3	2003-04	2003-04
Total	571.3	42	13.6		
Inflation Adjusted	710.1	42	16.9		
04. Transport, comms, other infrastructures					
Payments to Austroads/ARRB Transport Research Ltd.	94.1	42	2.2	1978-79	2019-20
Australian Housing and Urban Research Institute Limited (AHURI Ltd) National Housing Research Program	17.2	11	1.6	2009-10	2019-20
Used Car Safety Rating	0.3	10	0.0	2009-10	2018-19
Building Information Technology Strengths – Incubators	107.6	18	6.0	1999-00	2007-08
ANCAP-Vehicle Testing/Stars on Cars	9.4	9	1.0	2009-10	2017-18
Funding to Transport Certification Australia - Heavy vehicle telematics and the Intelligent Access Project	5.5	9	0.6	2009-10	2017-18
Information Technology Online (ITOL)	14.0	8	1.8	1999-00	2006-07
Building Information Technology Strengths – Advanced Networks program	57.3	6	9.6	2001-02	2006-07
Establishment of an ICT-enabled Research Laboratory - Commonwealth Assistance	22.0	6	3.7	2010-11	2015-16
Shipbuilding Innovation Scheme	38.3	6	6.4	1999-00	2004-05
Société Internationale de Télécommunications Aéronautiques	9.4	7	1.3	1998-99	2003-04
Australian Railway R&D Organisation	2.8	8	0.4	1981-82	1985-86
Low Volume Roads Research	2.5	4	0.6	2007-08	2010-11
Intelligent Transport Cooperative Research Centre	2.0	3	0.7	2017-18	2019-20
Transport planning and research	19.6	3	6.5	1978-79	1980-81
Air Cargo X-ray Trials	8.8	2	4.4	2006-07	2007-08
Liquids, Aerosols and Gels Screening Technology Trials	4.4	2	2.2	2007-08	2008-09
Study on the effectiveness of ABS for motorcycles	0.0	2	0.0	2013-14	2014-15
CSIRO-water resources assessment on Norfolk Island	0.5	1	0.5	2018-19	2018-19
International study on the effectiveness of advanced emergency braking systems for light vehicles	0.0	1	0.0	2013-14	2013-14
International Study on the Effectiveness of Reversing cameras	0.1	1	0.1	2012-13	2012-13
Joint Liquids, Aerosols and Gels Trial	0.2	1	0.2	2010-11	2010-11
Teledyne - Stand-Off Body Scanner project	0.1	1	0.1	2010-11	2010-11
University of Tasmania - Pre-Blast Explosive Analyser project	0.1	1	0.1	2010-11	2010-11
Total	416.1	42	9.9		
Inflation Adjusted	665.0	42	15.8		
05. Energy					
Energy Research	232.3	21	11.1	1978-79	1998-99
Low Emissions Technology Demonstration Fund	64.6	6	10.8	2004-05	2016-17

Program / Activity	Total Expenditure 1989-90 to 2019-20	Number of Years Operating	Average Program Expenditure Per Annuum	First year	Last year
Australian Renewable Energy Agency (ARENA)	1,877.8	11	170.7	2009-10	2019-20
Renewable Energy Equity Fund	20.1	10	2.0	1998-99	2007-08
Carbon Capture and Storage (CCS) Flagships	257.8	10	25.8	2009-10	2018-19
National Low Emissions Coal Initiative	233.3	10	23.3	2007-08	2016-17
Coal Mining Abatement Technology Support Package	28.7	8	3.6	2012-13	2019-20
Renewable Energy Commercialisation program	40.2	7	5.7	2000-01	2006-07
Energy Use Data Project - National Energy Analytics Research Program (NEAR)	11.0	3	3.7	2014-15	2019-20
Wind Forecasting Capability	13.9	5	2.8	2004-05	2008-09
Global Carbon Capture and Storage Institute	342.3	5	68.5	2008-09	2012-13
Advanced Electricity Storage Technologies	12.2	4	3.0	2005-06	2008-09
Clean Energy Initiative (Education Investment Fund)	94.1	5	18.8	2012-13	2014-15
Newcastle Institute for Energy and Resources	30.0	3	10.0	2010-11	2012-13
Sustainable Energy for SKA	47.3	3	15.8	2011-12	2013-14
Otway Basin Pilot Project	3.0	2	1.5	2007-08	2009-10
Retrofitting for Resilient and Sustainable Buildings	25.1	2	12.6	2010-11	2011-12
Climate projections and services for the energy sector	3.9	2	2.0	2018-19	2019-20
Energy Innovation Fund	5.8	1	5.8	2008-09	2008-09
Renewable Energy Fund	4.9	1	4.9	2008-09	2008-09
Total	3,348.4	42	79.7		
Inflation Adjusted	3,847.3	42	91.6		
06. Industrial production and technology					
Cooperative Research Centres Programme	4,351.0	29	150.0	1991-92	2019-20
National Measurement Institute (NMI)	127.3	16	8.0	2004-05	2019-20
Assistance under the Bounty (Computers) Act 1984	688.2	15	45.9	1984-85	1998-99
ICT Centre of Excellence	305.6	14	21.8	2002-03	2015-16
Public interest projects	46.6	12	3.9	1978-79	1991-92
Commercialising Emerging Technologies (COMET)	114.1	13	8.8	1999-00	2010-11
Project grants	268.9	12	22.4	1978-79	1989-90
Automotive Competitiveness Investment Scheme	1,650.8	11	150.1	2000-01	2010-11
Automotive Transformation Scheme	1,196.6	10	119.7	2010-11	2019-20
Technology Development Program	14.4	10	1.4	1982-83	1991-92
Enterprise Connect - Researchers in Business	11.4	9	1.3	2007-08	2015-16
Commercial Ready Program	852.2	8	106.5	2004-05	2011-12
Industry Innovation Programme	475.6	7	67.9	1992-93	1998-99
Motor Vehicle R&D	78.8	7	11.3	1984-85	1990-91
R&D Start Loans Program	76.3	7	10.9	1999-00	2005-06
Research Associations	12.0	8	1.5	1981-82	1987-88
Tax Deduction for equity subscriptions in Management Investment Companies (MICs) 8	140.0	7	20.0	1984-85	1990-91
Tax Deduction for Patents Designs and Copyright	193.0	7	27.6	1994-95	2000-01
Super Science - Future Industries	454.0	6	75.7	2008-09	2013-14
Entrepreneurs' Programme - Innovation Connection Grants	51.4	6	8.6	2014-15	2019-20
Green Car Innovation Fund	349.9	7	50.0	2009-10	2014-15
Industry Cooperative Innovation Program	21.0	6	3.5	2005-06	2010-11
IR&D Act 1986 (GIRD)	162.0	6	27.0	1986-87	1991-92
Motor Vehicle Producer R&D Scheme	84.8	6	14.1	2005-06	2010-11
Software-Engineering Australia	6.4	3	2.1	1998-99	2003-04
Technology Diffusion Program	74.2	6	12.4	1998-99	2003-04
Industry Growth Centres Initiative - Project Fund	23.3	5	4.7	2015-16	2019-20
Clean Technology Innovation Programme	31.0	8	3.9	2012-13	2016-17
Industry Innovation Program (includes R&D Start Grants)	765.5	6	127.6	1999-00	2003-04
Kraft Pulp Mill study (CSIRO)	7.6	5	1.5	1989-90	1993-94
National Procurement Development Program (NPDP)	18.8	5	3.8	1987-88	1991-92
Commonwealth Technology Port	22.5	5	4.5	1999-00	2002-03
Green Chemical Futures	29.1	6	4.9	2010-11	2013-14
Clean Business Australia - Climate Ready Program	76.1	6	12.7	2008-09	2011-12
National Enabling Technologies Strategy	2.1	6	0.4	2009-10	2012-13
Technology Support Centres	37.0	4	9.3	1994-95	1997-98
Test-It	3.1	4	0.8	1999-00	2002-03
Australian Future Fibres Research and Innovation Centres	37.0	3	12.3	2010-11	2012-13
Maintaining Engineering Excellence	4.3	3	1.4	2017-18	2019-20
Advanced Manufacturing Early Stage Research Fund (AMESRF)	3.0	3	1.0	2017-18	2019-20
Biotechnology Innovation Fund	29.3	3	9.8	2001-02	2003-04
Building Information Technology Strengths – Intelligent Island (Tas.)	40.0	2	20.0	1999-00	2001-02
Innovation Access Program – Industry (IAccP)	18.1	3	6.0	2002-03	2004-05
Regional and Rural Research and Information and Data Program	0.2	3	0.1	2002-03	2004-05
Australian Institute for Innovative Materials	43.8	2	21.9	2009-10	2010-11
Cairns Institute Tropical Innovation Hub - Contribution	19.5	2	9.8	2010-11	2011-12
Intermediary Access Program (Pilot)	4.0	2	2.0	2006-07	2007-08
Advanced Manufacturing Technology Program	0.1	1	0.1	1991-92	1991-92
Australian Technology Group Pty Ltd	30.0	1	30.0	1992-93	1992-93
Total	13,051.8	42	310.8		
Inflation Adjusted	18,440.7	42	439.1		
07. Health					
NHMRC Research Grants	14,513.6	42	345.6	1978-79	2019-20
Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) - Radiation in Health Care - Safe and Better Use	31.8	19	1.7	1992-93	2019-20
Australian Longitudinal Study on Women's Health	41.9	25	1.7	1995-96	2019-20
Capital Works for Medical Institutes	87.2	18	4.8	1979-80	1998-99
Anti-doping Research Program (ADRP)	11.4	15	0.8	2001-02	2017-18
Drug and Alcohol Research	89.0	10	8.9	2004-05	2019-20
Commonwealth Serum Laboratories (CSL)	135.1	16	8.4	1978-79	1993-94
Priority-driven Collaborative Cancer Research Scheme	74.5	15	5.0	2005-06	2019-20
Australian Institute of Health & Welfare (excl. grants)	65.7	16	4.1	1979-80	1993-94
National Centre for Immunisation Research and Surveillance	8.8	15	0.6	2002-03	2016-17
Support for Cancer Clinical Trials	83.2	14	5.9	2006-07	2019-20
AIDS Research	113.7	14	8.1	1985-86	1998-99
Repatriation Medical Authority	21.9	12	1.8	2008-09	2019-20
Australian Sports Commission (ASC) Research Programs - Intramural	12.0	11	1.1	2009-10	2019-20
Cancer data to improve cancer care	5.3	11	0.5	2009-10	2019-20
Cooperative Research Centre for Aboriginal and Torres Strait Islander Health	2.1	11	0.2	2003-04	2013-14
Health Surveillance Fund - Research Centres	99.5	11	9.0	2005-06	2015-16
Palliative Care Clinical Studies Collaborative	21.0	11	1.9	2006-07	2016-17
Department of Veterans' Affairs Applied Research Program	24.8	11	2.3	2009-10	2019-20
Phoenix Australia - Centre for Posttraumatic Mental Health	14.8	11	1.3	2009-10	2019-20
National Acoustic Laboratories	43.2	10	4.3	2010-11	2019-20
Australian Longitudinal Study on Male Health	18.1	10	1.8	2010-11	2019-20
Juvenile Diabetes Research Foundation - Australian Type 1 Diabetes Clinical Research Network	6.5	2	3.3	2010-11	2019-20
Improving lung cancer outcomes	4.7	9	0.5	2010-11	2019-20
Chronic Disease Prevention and Service Improvement Fund	23.5	10	2.4	2006-07	2015-16
Three dedicated Australian Prostate Cancer Research Centres (two centres funded from 2008-09 and a third from 2013-14)	37.5	12	3.1	2008-09	2017-18
Australian National Stem Cell Centre	49.4	10	4.9	2001-02	2010-11
Centre for Military and Veterans' Health	9.7	13	0.7	2004-05	2013-14
Indigenous Public Health Workforce Capacity Building Project, University of Melbourne (ONEMDA) and Deakin University Institute of Koori Education	4.2	13	0.3	2004-05	2012-13
Primary Care Policy, Innovation and Research	105.6	13	8.1	2005-06	2013-14
National Health Survey	12.3	8	1.5	2012-13	2019-20
Review of the 2006 Nutrient Reference Values for Australia and New Zealand	1.4	7	0.2	2012-13	2019-20
Maintaining support for women with gynaecological cancers	6.7	7	1.0	2013-14	2019-20
Australian Sports Commission (ASC) Research Programs - Extramural	2.2	7	0.3	2013-14	2019-20
Malaria Vaccine Joint Venture	15.2	7	2.2	1985-86	1991-92
Health and Hospitals Fund	430.3	6	71.7	2008-09	2013-14
Investing in Hearing Research	6.1	6	1.0	2007-08	2012-13
Primary Health Care Research Evaluation and Development - Primary Health Care Research and Information Service	7.5	6	1.2	2011-12	2016-17
Support for Diabetes Research	32.1	11	2.9	2004-05	2009-10
Pharmaceutical Industry Investment Program	104.9	11	9.5	1999-00	2004-05
Veteran Health Research	7.8	6	1.3	2014-15	2019-20
Pharmacy Trial Program	49.7	5	9.9	2015-16	2019-20
Head to Health Digital Gateway	25.7	5	5.1	2015-16	2019-20

Program / Activity	Total Expenditure 1989-90 to 2019-20	Number of Years Operating	Average Program Expenditure Per Annuum	First year	Last year
Per- & Poly-fluoroalkyl Substances Epidemiological Study	5.9	5	1.2	2015-16	2019-20
Australian Burden of Disease Study	7.2	5	1.4	2012-13	2016-17
Australian National Preventive Health Agency Research Fund	18.9	5	3.8	2011-12	2015-16
Bettering the Evaluation and Care of Health - BEACH	1.6	5	0.3	2011-12	2015-16
National Breast Cancer Foundation Cohort Study	2.5	5	0.5	2008-09	2012-13
Pharmaceutical Partnerships Program	90.4	6	15.1	2004-05	2008-09
Medical Research Future Fund	776.4	4	194.1	2016-17	2019-20
Biomedical Translation Fund	112.4	4	28.1	2016-17	2019-20
National Suicide Prevention Trial	48.0	4	12.0	2016-17	2019-20
Suicide Prevention Research Fund	12.3	4	3.1	2016-17	2019-20
Primary Health Network Mental Health Lead Site Evaluation	6.0	4	1.5	2016-17	2019-20
Health Policy Research and Data Program - National Maternal and Perinatal Mortality and Morbidity Data Collection Phase 2	4.5	4	1.1	2016-17	2019-20
National Leadership Role in Suicide Prevention Research	2.1	4	0.5	2016-17	2019-20
Adult Stem Cell Research Centre	20.0	4	5.0	2006-07	2009-10
Jigsaw Foundation - Support for craniofacial surgery	5.0	4	1.3	2010-11	2013-14
Medical Research Infrastructure Projects	682.0	4	170.5	2003-04	2006-07
Primary Health Care Research Evaluation and Development - Australian Primary Health Care Research Institute	35.6	4	8.9	2011-12	2014-15
Review of the Mandatory Fortification of Bread	0.4	6	0.1	2013-14	2016-17
Commonwealth Serum Laboratories (CSL) - Commonwealth assistance	30.0	4	7.5	2010-11	2013-14
Department of Veterans' Affairs - Family Study Research	2.1	4	0.5	2011-12	2014-15
Centre for Neural Engineering	17.5	3	5.8	2009-10	2011-12
Telethon ORIGINS project	3.9	3	1.3	2017-18	2019-20
National Mental Health Service Planning Framework - Further Development	2.8	3	0.9	2017-18	2019-20
Investing in Medical Research - fighting childhood cancer	4.5	3	1.5	2017-18	2019-20
Disease Prevention and Health Promotion in Medicare Locals Programme	4.5	3	1.5	2012-13	2014-15
Health Policy Research & Data Program - Blood Borne Viruses and Sexually Transmitted Infections	14.0	3	4.7	2016-17	2018-19
Health Policy Research and Data Program - Multiple Sclerosis Research	0.8	3	0.3	2016-17	2018-19
Health Policy Research and Data Program - Primary Care Research	4.5	3	1.5	2016-17	2018-19
Health Protection Program	11.9	3	4.0	2016-17	2018-19
National Cancer Plan - Boost Cancer Research	15.1	3	5.0	2008-09	2010-11
Pandemic Vaccine Accelerated Development	6.9	3	2.3	2005-06	2007-08
Population Health Research Network	3.1	2	1.5	2012-13	2013-14
Australian Genomic Cancer Medicine Program	20.0	2	10.0	2018-19	2019-20
Sports Integrity Program - Anti Doping Research	0.4	2	0.2	2018-19	2019-20
Analysis of poorly entered GP data	0.1	2	0.1	2016-17	2017-18
Medicines Post-Marketing Surveillance Using the 45 and Up Study and Services Linked Datasets	0.1	2	0.1	2015-16	2016-17
Prioritising Mental Health - Research Grants	10.0	2	5.0	2017-18	2018-19
Bond University - Grant for Health Science and Medicine Building	4.5	1	4.5	2005-06	2005-06
Smart State Medical Research Centre	55.0	1	55.0	2010-11	2010-11
Lowitja Institute Research Funding	4.0	1	4.0	2019-20	2019-20
45+ Study	0.1	1	0.1	2014-15	2014-15
Aboriginal and Torres Strait Islander Health Research Special Initiative	3.4	1	3.4	2014-15	2014-15
Australian Prostate Cancer Research Centre - NSW	0.4	1	0.4	2018-19	2018-19
Australian Prostate Centre, Victoria	0.6	1	0.6	2018-19	2018-19
Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) - Wi-Fi in Schools Measurement Study	0.2	1	0.2	2016-17	2016-17
Cure4MND	2.8	1	2.8	2016-17	2016-17
National health literacy Survey	1.4	1	1.4	2016-17	2016-17
Research for Australian Dietary Guidelines	0.1	1	0.1	2012-13	2012-13
Research on Fetal Alcohol Spectrum Disorder (FASD)	1.4	1	1.4	2016-17	2016-17
Review of the Australian Radiation Protection and Nuclear Safety Act 1998	0.2	1	0.2	2011-12	2011-12
St George and Sutherland Medical Research Foundation - Microbiome Research Centre	4.0	1	4.0	2016-17	2016-17
Supporting women in rural areas diagnosed with breast cancer	0.2	1	0.2	2016-17	2016-17
Total	17,700.4	40	442.5		
Inflation Adjusted	21,714.3	42	517.0		
08. Agriculture					
Fisheries Research and Development Corporation	568.9	42	13.5	1978-79	2019-20
Australian Wool Innovation Limited	536.0	42	12.8	1978-79	2019-20
Grains Research and Development Corporation	1,404.5	41	34.3	1979-80	2019-20
Meat Research	910.9	38	24.0	1978-79	2015-16
Other Rural Research	869.3	38	22.9	1978-79	2015-16
Rural Industries R&D Corporation	320.1	34	9.4	1982-83	2015-16
Horticulture Innovation Australia Limited	867.1	36	24.1	1988-89	2019-20
Australian Animal Health Laboratory (AAHL)	109.6	20	5.5	1984-85	2003-04
Australian Centre for International Agricultural Research (ACIAR)	1,494.8	20	74.7	2000-01	2019-20
Dairy Australia Limited	316.5	17	18.6	2003-04	2019-20
Centres of Excellence - Biosecurity Risk Analysis and Research	26.5	16	1.7	2004-05	2019-20
Fisheries Resources Research Fund	28.6	16	1.8	2004-05	2019-20
AgriFutures Australia - Bill 1 Appropriation	113.5	11	10.3	2009-10	2019-20
Plant Biosecurity and Response Reform	0.7	7	0.1	2010-11	2016-17
A Competitive Agriculture Sector - boosting farm profits through rural R&D	118.3	6	19.7	2014-15	2019-20
Forest and Wood Products Australia Limited	32.0	6	5.3	2014-15	2019-20
Australian Eggs Limited	11.5	5	2.3	2015-16	2019-20
Meat and Livestock Australia Limited	297.5	4	74.4	2016-17	2019-20
AgriFutures Australia	30.2	4	7.5	2016-17	2019-20
Wine Australia	53.3	4	13.3	2016-17	2019-20
Sugar Research Australia Limited	26.9	4	6.7	2016-17	2019-20
Cotton Research and Development Corporation	30.2	4	7.6	2016-17	2019-20
Australian Pork Limited	21.7	4	5.4	2016-17	2019-20
Northern Australia Rice Industry	4.1	4	1.0	2016-17	2019-20
Climate Change Research Program	46.2	4	11.5	2008-09	2011-12
National Weeds and Productivity Research Program	15.2	4	3.8	2008-09	2011-12
Project Agreement for managing established pest animals and weeds	18.9	4	4.7	2015-16	2018-19
Centre for Invasive Species Solutions	12.0	3	4.0	2017-18	2019-20
National Carp Control Plan	10.2	3	3.4	2016-17	2018-19
National Landcare Programme Innovation Grants	22.1	3	7.4	2013-14	2015-16
National Landcare Program - Smart Farming Partnerships	27.3	2	13.7	2018-19	2019-20
National Landcare Program - Smart Farms Small Grants	19.0	2	9.5	2018-19	2019-20
Smart Fruit Fly Management - Collaborative national approach	2.8	2	1.4	2018-19	2019-20
Forest Industry Climate Change Research Fund	4.8	2	2.4	2009-10	2010-11
Total	8,371.3	42	199.3		
Inflation Adjusted	11,143.5	42	265.3		
09. Education					
Education R&D Grants	4.2	5	0.8	1978-79	1982-83
Bond University - Grant for Clinical Education and Research Centre Building	2.5	2	1.3	2008-09	2008-09
Total	6.7	6	1.1		
Inflation Adjusted	20.0	6	3.3		
10. Culture, recreation, religion and mass media					
Australia Council - Synapse program	1.5	12	0.1	2003-04	2015-16
Australian National Maritime Museum	1.9	10	0.2	2008-09	2017-18
ARC Linkage Grants - NMA Contribution	0.5	9	0.1	2005-06	2013-14
ARC Linkage Grant - Cultures of coast and sea: maritime environmental, cultural and ethnographic histories of northeast Australia	0.4	3	0.1	2011-12	2013-14
ARC Linkage Grant - Return, Reconcile, Renew: understanding the history, effects and opportunities of repatriation and building an evidence base for the future.	0.3	3	0.1	2013-14	2015-16
ARC Linkage Grants - Australian National Maritime Museum	0.1	3	0.0	2015-16	2017-18
ARC Linkage Grant - Restoring Dignity: Networked Knowledge for Repatriation Communities	0.2	2	0.1	2017-18	2018-19
Total	5.0	16	0.3		
Inflation Adjusted	5.5	16	0.3		
11. Political and social systemss					
Australian Institute of Criminology (AIC) Research Program	64.0	18	3.6	2002-03	2019-20
Australian Institute of Criminology (AIC) - Criminology Research Grant Program	9.3	18	0.5	2002-03	2019-20
Longitudinal Study of Indigenous Children (LSIC)	54.9	15	3.7	2005-06	2019-20
Gambling Research Australia	3.5	9	0.4	2005-06	2019-20
Personal Safety Survey (Australian Bureau of Statistics)	34.5	10	3.4	2006-07	2019-20
DFAT Aid Research and Development	961.2	13	73.9	2005-06	2017-18

Program / Activity	Total Expenditure 1989-90 to 2019-20	Number of Years Operating	Average Program Expenditure Per Annuum	First year	Last year
National Survey on Community Attitudes to Violence Against Women (VicHealth and then ANROWS from June 2016)	9.2	10	0.9	2008-09	2019-20
National Disability Research and Development Agenda	11.1	11	1.0	2009-10	2019-20
Household, Income and Labour Dynamics in Australia (HILDA) Survey	106.1	10	10.6	2010-11	2019-20
Longitudinal Survey of Australian Children (LSAC)	78.6	10	7.9	2011-12	2019-20
Building a New Life in Australia (BNLA) Longitudinal Study of Humanitarian Migrants (Australian Institute of Family Studies)	13.2	10	1.3	2011-12	2019-20
Commonwealth-ANU Strategic Relationship	12.3	8	1.5	2010-11	2017-18
Indigenous Populations project (CAEPR)	3.2	8	0.4	2010-11	2017-18
Australian Institute of Criminology (AIC) - National Drug and Law Enforcement Research Program	4.4	8	0.6	2010-11	2016-17
ARC Linkage Grant - Centre of Excellence for Children and Families over the Life Course	1.2	10	0.1	2013-14	2019-20
ARC Linkage Grant - Creating pathways to child wellbeing in disadvantaged communities	1.4	10	0.1	2012-13	2018-19
Strategic Indigenous Research (CAEPR)	2.2	10	0.2	2010-11	2015-16
Child Family Community Australia (CFCA) Information Exchange (AIFS)	5.6	10	0.6	2014-15	2019-20
Families and Children (FaC) Activity Expert Panel Project	5.5	10	0.6	2014-15	2019-20
Human Services Delivery Research Alliance	9.3	5	1.9	2009-10	2013-14
Closing the Gap Clearinghouse	2.6	5	0.5	2008-09	2012-13
Desert Knowledge Co-operative Research Centre	2.5	5	0.5	2005-06	2009-10
ANROWS core funding	7.2	5	1.4	2012-13	2016-17
ARC Linkage Grants - FaHCSIA Cash Contributions	1.1	5	0.2	2007-08	2011-12
Data Reporting and Collection Framework and associated research - ABS	1.2	5	0.2	2012-13	2016-17
Longitudinal study - Journey's Home	8.5	5	1.7	2010-11	2014-15
Paid Parental Leave Evaluation	3.3	5	0.7	2009-10	2013-14
Research under the National Framework for Protecting Australia's Children 2009-2020	3.0	5	0.6	2012-13	2016-17
Australian National Institute for Public Policy	4.9	4	1.2	2010-11	2013-14
National Climate Change Adaptation Research Facility (NCCARF) - support	9.1	6	1.5	2014-15	2017-18
Domestic Violence Research	0.3	5	0.1	2015-16	2018-19
ANROWS Core Agreement 16-23	6.8	4	1.7	2016-17	2019-20
Restacking the Odds (Murdoch Childrens Research Institute)	0.5	4	0.1	2016-17	2019-20
Safe at Home project (UNSW)	0.6	4	0.2	2016-17	2019-20
Building the Australian Centre on China in the World	18.1	3	6.0	2010-11	2012-13
Regional Australia Institute - National Program of Inquiry	1.2	3	0.4	2017-18	2019-20
ARC Linkage Grant - A study of the impact of income support design on the outcomes of children and youth	0.2	3	0.1	2017-18	2019-20
Indigenous Research Fund	10.0	3	3.3	2017-18	2019-20
Cooperative Research Centre for Remote Economic Participation	0.8	3	0.3	2010-11	2012-13
Improved Indigenous population projections for policy and planning	0.1	3	0.0	2013-14	2015-16
Menzies	0.9	3	0.3	2015-16	2017-18
Poverty in the midst of plenty	0.3	3	0.1	2009-10	2011-12
The Implementation of Agreements and Treaties with Indigenous and Local Peoples in Postcolonial States	0.3	3	0.1	2006-07	2008-09
Victorian Aboriginal Child Mortality Study	0.6	3	0.2	2012-13	2014-15
ABS Directory of Family and Domestic Violence Statistics	0.3	3	0.1	2017-18	2019-20
Family Violence in newly-arrived migrant and refugee communities (Uni Melbourne)	0.6	3	0.2	2017-18	2019-20
ABS Recorded Crime, Criminal Courts, Corrective Services FDSV statistics	1.9	3	0.6	2016-17	2018-19
AIHW Cross-Jurisdictional Data Sharing Project (FDSV)	0.7	3	0.2	2016-17	2018-19
ANROWS Perpetrator Intervention Research Stream	3.0	3	1.0	2012-13	2014-15
ARC Linkage Grant - Enhancing mothers' engagement with the workforce in the preschool years (Millennium Mums survey)	0.5	3	0.2	2013-14	2015-16
Giving Australia	1.8	3	0.6	2014-15	2016-17
Intercountry Adoption – Australian / International based research	0.3	3	0.1	2014-15	2016-17
Study on FDSV in Aboriginal and Torres Strait Islander communities (ANU)	4.4	3	1.5	2016-17	2018-19
Building the National Security College	0.3	2	0.1	2010-11	2011-12
ARC Linkage Grant - Protecting the Australian Passport	0.2	4	0.1	2013-14	2014-15
Tourism Research Australia - Development of survey methodology	0.3	4	0.1	2013-14	2014-15
Australian Institute of Criminology (AIC) - Serious and Organised Crime Research Laboratory	2.0	4	0.5	2018-19	2019-20
Australian Institute of Criminology (AIC) - Child Exploitation Material Reduction Research Program	1.3	4	0.3	2018-19	2019-20
Service Delivery Reform Research	0.2	2	0.1	2010-11	2011-12
AHRC Death Review scoping paper	0.1	2	0.1	2016-17	2017-18
AHRC Fourth Wave of the National Sexual Harassment Survey	0.4	2	0.2	2016-17	2017-18
ANROWS National Risk Assessment Principles	0.1	2	0.1	2016-17	2017-18
ANROWS Perpetrator Research (Additional Trials)	0.4	2	0.2	2017-18	2018-19
ARC Linkage Grant - Building successful diverse communities: What works and why	0.1	2	0.1	2012-13	2013-14
BSCW Action Research	0.6	2	0.3	2015-16	2016-17
Capacity Building - Working with Children (ACU)	0.3	2	0.2	2017-18	2018-19
Capacity Building Project (iHeal trial, Drummond Street)	0.3	2	0.1	2016-17	2017-18
Cultural and Linguistically Diverse Projects Action Research	0.4	2	0.2	2017-18	2018-19
Family Reunification after FDV (Uni SA)	0.4	2	0.2	2017-18	2018-19
Kids in Communities Study (Murdoch Childrens Research Institute)	0.2	2	0.1	2016-17	2017-18
National Survey of Family and Relationship Services and Specialist Family Violence Services (AIFS)	0.1	2	0.1	2016-17	2017-18
National survey on the impact of tenancy laws on women and children escaping violence (Uni SA)	0.1	2	0.1	2017-18	2018-19
Outcomes Measurement (Drummond Street)	0.5	2	0.2	2017-18	2018-19
Perpetrator programs - Female perpetrators (Uni Melbourne)	0.3	2	0.1	2017-18	2018-19
Perpetrator Programs - LGBTIQ Perpetrators (Drummond Street)	0.2	2	0.1	2017-18	2018-19
Perpetrator Programs - Young Perpetrators (University of Newcastle)	0.6	2	0.3	2017-18	2018-19
Research projects under the Social Policy Research Investment Strategy (SPRIS)	0.3	2	0.2	2011-12	2012-13
Resources on how to obtain consent when working with Aboriginal and Torres Strait Islander children who have experienced family and domestic violence (ACU)	0.1	2	0.0	2016-17	2017-18
Service system responses to the needs of children to keep them safe from violence (ACU)	0.1	2	0.1	2016-17	2017-18
University of New South Wales. National Workforce Survey (FDSV)	0.5	2	0.3	2016-17	2017-18
Australia Consensus	0.6	1	0.6	2015-16	2015-16
Centre on China in the World	35.0	1	35.0	2010-11	2010-11
Sir Roland Wilson Foundation	7.0	1	7.0	2010-11	2010-11
ILO Regional Research Project - Women and the Future of Work in the Asia-Pacific	0.2	1	0.2	2016-17	2016-17
ANROWS Diversity Data	0.2	1	0.2	2015-16	2015-16
ANROWS Qualitative Sexual Assault & Young People Research	0.5	2	0.3	2018-19	2018-19
Children's Experiences and Views of Family Violence (ACU)	0.1	1	0.1	2015-16	2015-16
Consultations with faith communities about FDSV (ANU)	0.1	1	0.1	2017-18	2017-18
Effects of Pornography on Young People (AIFS)	0.1	1	0.1	2015-16	2015-16
Independent research and evaluation of key assumptions around the impact of problem and recreational gamblers	0.0	1	0.0	2011-12	2011-12
Independent study on impacts of problem gambling	0.3	1	0.3	2011-12	2011-12
Meta-synthesis of qualitatve research with children (ACU)	0.1	1	0.1	2015-16	2015-16
NHMRC - Latrobe University Hamrony Project	0.2	1	0.2	2017-18	2017-18
Research selected responses to the ALSWH using the composite abuse scale (University of Newcastle)	0.1	1	0.1	2017-18	2017-18
Total	1,543.0	18	85.7		
Inflation Adjusted	1,653.3	18	91.8		
12. General advancement of knowledge					
Australian Biological Resources Study	75.7	42	1.8	1978-79	2019-20
National Institutes Program - ANU Component	5,830.6	42	138.8	1981-82	2019-20
Estimate of Other Research and Research Training Support Sourced from the Australian Government	12,462.5	26	479.3	1978-79	2003-04
International Science Linkages	143.7	30	4.8	1988-89	2010-11
Special Research Assistance	3,463.7	23	150.6	1981-82	1999-00
Australian Postgraduate Awards	2,587.3	17	152.2	2000-01	2016-17
International Postgraduate Research Scholarship (IPRS)	318.6	17	18.7	2000-01	2016-17
Research Infrastructure Block Grants	3,202.4	17	188.4	2000-01	2016-17
Research Training Scheme	9,840.3	17	578.8	2000-01	2016-17
Australian War Memorial - Official Histories	11.7	17	0.7	2003-04	2019-20
ARGS & ARC grants/fellowships (including marine R&D grants)	349.3	13	26.9	1978-79	1990-91
Australia-India Strategic Research Fund	71.1	13	5.5	2007-08	2019-20
Post-graduate Awards	167.6	12	14.0	1978-79	1989-90
Regional and Rural Research and Development Grants	2.1	11	0.2	2002-03	2013-14
Major National Research Facilities (MNRF)	217.2	11	19.7	1995-96	2005-06
Research Evaluation and Grants for Learned Academies	23.3	11	2.1	1990-91	2000-01
Institutional Grants Scheme	2,757.1	10	275.7	2000-01	2009-10

Program / Activity	Total Expenditure 1989-90 to 2019-20	Number of Years Operating	Average Program Expenditure Per Annuum	First year	Last year
Bush Blitz Strategic Taxonomy Grants Scheme	5.2	7	0.7	2010-11	2019-20
Targeted Institutional Links Programme	8.9	9	1.0	1989-90	1997-98
Australia-China Science and Research Fund	21.8	9	2.4	2011-12	2019-20
Joint Research Engagement Program	2,380.5	8	297.6	2009-10	2016-17
Regional Protection Scheme	28.2	8	3.5	2001-02	2008-09
Sustainable Research Excellence in Universities	1,116.4	8	139.6	2009-10	2016-17
Commercialisation Training Scheme	31.2	7	4.5	2005-06	2011-12
Systemic Infrastructure Initiative	241.7	6	40.3	2001-02	2006-07
Collaborative Research Networks Program	81.1	8	10.1	2010-11	2015-16
New Horizons - Monash University Project	89.9	6	15.0	2008-09	2013-14
Research Quantum (RQ)	1,197.0	5	239.4	1995-96	1999-00
Research Training Component (RTC)	2,333.4	5	466.7	1995-96	1999-00
Institute of Photonics	28.8	5	5.8	2008-09	2012-13
Learned Academies Supplementation funding	5.0	5	1.0	2008-09	2012-13
The Australian Institute for Nanoscience	40.0	5	8.0	2010-11	2014-15
Research Training Program	3,588.9	4	897.2	2016-17	2019-20
Research Support Program	3,122.0	4	780.5	2016-17	2019-20
Academic Centres of Cyber Security Excellence	1.9	4	0.5	2016-17	2019-20
Institute of Molecular Bioscience	15.0	8	1.9	1999-00	2002-03
Global Innovation Strategy	27.7	4	6.9	2016-17	2019-20
Quantum Computing (NISA)	20.0	4	5.0	2016-17	2019-20
European Molecular Biology Laboratory Partner Facility	8.0	4	2.0	2009-10	2012-13
Small-Scale Mammalian Cell Production Facility	10.0	4	2.5	2009-10	2012-13
ANZAC Day at home and abroad: A centenary history of Australia's National Day	0.3	5	0.1	2010-11	2013-14
La Trobe Institute for Molecular Sciences	64.1	3	21.4	2009-10	2011-12
National Centre for Synchrotron Science	36.8	3	12.3	2009-10	2011-12
Access to World-leading Astronomy Infrastructure	31.5	4	7.9	2017-18	2019-20
Inspiring Australia - Higher Education Research Promotion (HERP) component	1.4	3	0.5	2011-12	2013-14
Science Lectureships	14.9	4	3.7	1999-00	2000-01
Astronomy National Research Infrastructure	3.5	2	1.7	2012-13	2013-14
Australian Microscopy and Microanalysis Research Facility	5.1	2	2.5	2012-13	2013-14
Australian National Data Service	3.0	2	1.5	2012-13	2013-14
Australian National Fabrication Facility	7.3	2	3.7	2012-13	2013-14
Australian Phenomics Network	4.7	2	2.4	2012-13	2013-14
Australian Plant Phenomics Facility	3.3	2	1.6	2012-13	2013-14
Emerging Biomolecular Platforms and Informatics	4.5	2	2.2	2012-13	2013-14
Heavy Ion Accelerators	2.3	2	1.1	2012-13	2013-14
National Imaging Facility	4.3	2	2.1	2012-13	2013-14
National Imaging Facility	40.2	2	20.1	2010-11	2011-12
Australian National University Research Infrastructure Projects	125.0	1	125.0	2005-06	2005-06
Australian Synchrotron Contribution	50.0	1	50.0	2006-07	2006-07
Australian Synchrotron operating funding	7.5	1	7.5	2016-17	2016-17
Australian Synchrotron operating funding (NISA)	11.4	1	11.4	2016-17	2016-17
High Performance Computing - Pawsey	70.0	1	70.0	2017-18	2017-18
Total	56,417.5	42	1,343.3		
Inflation adjusted	84,956.0	42	2,022.8		
14. Defence					
Defence Science and Technology Group (DST Group)	12,178.9	42	290.0	1978-79	2019-20
Australian Civil-Military Centre - Research and Lessons Learnt	6.2	11	0.6	2009-10	2019-20
Defence Future Capability Technology Centre Program	45.5	10	4.6	2007-08	2016-17
Mental Health - LASER Resilience Research	2.2	9	0.2	2009-10	2018-19
Contamination Management and Remediation	17.4	6	2.9	2014-15	2019-20
Explosive Ordinance - Required materials for Proof and Equipment Unit	2.9	6	0.5	2014-15	2019-20
Capability Technology Demonstrator - Extension Program	43.9	6	7.3	2007-08	2012-13
Airfield Pavement Engineering Research through the Australian Airports Association	1.8	4	0.5	2016-17	2019-20
Jet Fuel Exposure Syndrome Study	2.8	4	0.7	2010-11	2013-14
Mental Health - Transition and Wellbeing Research Programme	1.6	4	0.4	2014-15	2017-18
Per-and Poly-Fluorinated Alkyl Substances - National Health Research Program	12.2	3	4.1	2017-18	2019-20
Joint Force Integration - IMD Study	1.1	3	0.4	2014-15	2016-17
Mental Health - Viability of Intensive Prolonged Exposure Therapy for Post Traumatic Stress Disorder (PTSD)	1.0	3	0.3	2015-16	2017-18
Mental Health Research and Evaluation - New Projects and Initiatives	1.5	1	1.5	2019-20	2019-20
Project Insight- Health Insight Capability	0.2	1	0.2	2019-20	2019-20
DSTG Research Projects - Blood Brain Barrier Model project	0.2	1	0.2	2019-20	2019-20
DSTG Research Projects - Hollow Fibre Infection Model project	0.2	1	0.2	2019-20	2019-20
Head Joint Enablers VCDF Group - Moral Injury	0.1	1	0.1	2016-17	2016-17
Joint Force Integration - JP2008PH5B1.2	0.6	1	0.6	2016-17	2016-17
Joint Force Integration - QINETIQ	0.2	1	0.2	2016-17	2016-17
Per- and Poly-Fluorinated Alkyl Substances - ARC Remediation Research Program	15.0	1	15.0	2017-18	2017-18
Total	12,335.5	42	293.7		
Inflation adjusted	18,855.9	42	448.9		
Nominal Expenditure	207,876.1	42	4,949.4		
Inflation Adjusted expenditure	287,809.5	42	6,852.6		

Attachment 6: Expenditure on non-R&D Innovation Programs 1978-79 – 2019-20

Program / Activity	Total Expenditure 1997-98 to 2019-20	No of Years Committed	Average Annual Program Expenditure Per Annum	First year	Last year
00. Multiple categories					
Priority pest and disease planning and surveillance and response	4.2	2	2.1	2018-19	2019-20
Data Integration Partnership for Australia	14.3	3	4.8	2017-18	2019-20
Embracing the Digital Age	48.8	4	12.2	2016-17	2019-20
Excellence in Research for Australia (ERA)	73.4	11	6.7	2009-10	2019-20
Industry Skills Fund	51.0	5	10.2	2014-15	2018-19
Inspiring STEM Literacy	14.0	4	3.5	2016-17	2019-20
Maths and Science Participation	21.7	6	3.6	2012-13	2017-18
Science, Technology, Engineering & Mathematics (STEM)	10.5	3	3.5	2015-16	2017-18
Supporting Artificial Intelligence in Schools	0.5	2	0.3	2018-19	2019-20
Additional Funding for Austrade Landing Pads	2.4	3	0.8	2016-17	2018-19
Global Innovation Strategy - Landing Pads	10.4	4	2.6	2016-17	2019-20
Data Integration Partnership for Australia	19.0	3	6.3	2017-18	2019-20
Data Integration Partnership for Australia	1.8	3	0.6	2017-18	2019-20
Development of a roadmap for AI standards	0.1	1	0.1	2018-19	2018-19
Open Geocoded National Address File	29.2	4	7.3	2015-16	2018-19
Data Integration Partnership for Australia	20.4	3	6.8	2017-18	2019-20
Data Integration Partnership for Australia	37.7	3	12.6	2017-18	2019-20
Tax Incentives for Early Stage Investors (Early Stage Innovation Company - ESIC)	115.0	4	28.8	2016-17	2019-20
Total	474.4	11	43.1		
01. Exploration and exploitation of the Earth					
Emerging Technologies Lab, Metinsight, Bureau of Meteorology	2.5	2	1.2	2016-17	2017-18
Total	2.5	2	1.2		
Total Inflation Adjusted	2.5	2	1.2		
02. Environment					
Mechanical Fuel Load Reduction Trial	1.5	2	0.8	2011-12	2019-20
Revision of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality	0.9	9	0.1	2011-12	2019-20
Australian Marine Parks Science Atlas	0.2	2	0.1	2016-17	2017-18
Behavioural Insights projects	0.3	4	0.1	2016-17	2019-20
National Plan for Environmental Information, Bureau of Meteorology	27.1	8	3.4	2011-11	2017-18
Reef Trust Innovation Challenge	1.5	1	1.5	2018-19	2018-19
Total	31.5	10	3.1		
03. Exploration and exploitation of space					
International Space Investment Initiative	3.0	1	3.0	2019-20	2019-20
Space Infrastructure Fund	6.3	2	3.1	2017-18	2019-20
Total	9.3	2	4.6	2017-18	2019-20
Total Inflation Adjusted	8.8	2	4.4		
04. Transport, telecommunications and other infrastructures					
Building Digital Capability	9.3	3	3.1	2017-18	2019-0
Build of physical innovation space	0.0	3	0.0		
Digital Platforms	28.3	3	9.4	2017-18	2019-0
Oversight of Significant Digital and ICT Intiatives	1.5	3	0.5	2017-18	2019-0
Total	39.0	3	13.0		
06. Industrial production and technology					
Centre for Defence Industry Capability (CDIC) Innovation initiatives	92.6	4	23.1	2016-17	2019-20
Secretary's Awards for Innovation	0.0	4	0.0		
Training, conferences and events in innovation related fields	0.1	4	0.0		
Renewable Energy, Energy Security Program	1.3	2	0.7	2018-19	2019-20
Automotive Innovation Labs	9.8	3	3.3	2017-18	2019-20
Business Research and Innovation Initiative (BRII)	23.5	4	5.9	2015-16	2019-20
Competitive Pre-Seed Fund	69.1	8	8.6	2002-03	2017-18
Entrepreneurs' Programme (excluding Single Service Delivery and Innovation Connection Grants)	442.7	6	73.8	2014-15	2019-20
Industry 4.0 Testlabs for Australia	5.7	1	5.7	2018-19	2018-19
Industry Growth Centres	23.3	5	4.7	2015-16	2019-20
Industry Growth Centres Initiative - Commercialisation Fund	75.7	6	12.6	2014-15	2019-20
Innovation Investment Fund including Innovation Investment Follow-on Fund	458.5	11	41.7	1997-78	2019-20
Inspiring Australia | Science Engagement Programme	36.1	4	9.0	2016-17	2019-20
Superstars of STEM	1.3	1	1.3	2017-18	2017-18
Victorian Innovation and Investment Fund (Geelong Region Innovation and Investment Fund and Melbourne's North Innovation and Investment Fund)	30.0	4	7.5	2013-14	2016-17
Women in STEM	2.9	2	1.4	2018-19	2019-20
Women in STEM and Entrepreneurship (WISE)	13.7	4	3.4	2015-16	2019-20
Total	1,286.2	11	116.9		
Total Inflation Adjusted	1,428.1	11	129.8		
07. Health					
Australian Tropical Medicine Commercialisation Grants	7.5	4	1.9	2015-16	2018-19
Australian Radiation Protection and Nuclear Safety Agency (ARPANSA) - Radiation Oncology	5.0	1	5.0	2017-18	2017-18
Australian Sports Commission (ASC) Innovation Programs - Extramural	8.4	7	1.2	2013-14	2019-20
Australian Sports Commission (ASC) Innovation Programs - Intramural	18.5	7	2.6	2013-14	2019-20
Dementia and Aged Care Services Research and Innovation Funding Round	45.5	4	11.4	2016-17	2019-20
Evaluation to the Tackling Indigenous Smoking Program	0.9	3	0.3	2015-16	2017-18
Insecticide Resistance Project for Exotic Mosquitoes	0.3	2	0.2	2017-18	2018-19
Commercialisation Australia	0.0	3	0.0		
Public Service Modernisation Fund - agency sustainability	8.5	3	2.8	2017-18	2019-20
Tackling Indigenous Smoking - Innovation Grants	6.3	3	2.1	2015-16	2017-18
Total	100.8	7	14.4		
Total Inflation Adjusted	100.4	7	14.3		
08. Agriculture					
Animal Welfare, Biosecurity and Exotic Disease Preparedness Programs	3.6	6	0.6	2004-05	2014-15
Carbon Farming Futures - Action on the Ground	43.3	6	7.2	2011-12	2016-17
Carbon Farming Futures - Extension and Outreach	24.3	6	4.0	2011-12	2016-17
Carbon Farming Futures - Filling the Research Gap	104.9	6	17.5	2011-12	2016-17
Carbon Farming Initiative	5.2	5	1.0	2010-11	2015-16
Established Pest Animals and Weeds Initiative	29.3	5	5.9	2015-16	2019-20
Improved Access to Agricultural and Veterinary Chemicals grants program	10.1	5	2.0	2015-16	2019-20
National Institute for Forest Products Innovation	3.2	4	0.8	2016-17	2019-20
Plant Biosecurity and Response Reform	11.4	8	1.4	2012-13	2019-20
Regional Food Producers/Seafood Industry Innovation and Productivity Program	8.5	3	2.8	2009-10	2011-12
Science and Innovation Awards for Young People in Agriculture, Fisheries and Forestry	1.6	11	0.1	2009-10	2019-20
Smart Fruit Fly Management - Commonwealth to lead reform	0.2	2	0.1	2018-19	2019-20
Stronger Farmers, Stronger Economy - Improvements to access premium markets - improve biosecurity	1.5	2	0.7	2016-17	2017-18
Wine Australia	48.0	3	16.0	2017-18	2019-20

Program / Activity	Total Expenditure 1997-98 to 2019-20	No of Years Committed	Average Annual Program Expenditure Per Annum	First year	Last year
Total	295.1	11	26.8		
Total Inflation Adjusted	303.8	11	27.6		
09. Education					
Australian Mathmatical Sciences Institute - Securing Australia's Mathematical Workforce	2.0	4	0.5	2016-17	2019-20
Pathways in Technology (P-TECH) Pilot	5.0	5	1.0	2015-16	2019-20
Total	7.0	5	1.4		
Total Inflation Adjusted	0.4	5	0.1		
10. Culture, recreation, religion and mass media					
Data Integration Partnership for Australia - Enhancement and Expansion of the DSS Data Exchange (DEX)	29.8	3	9.9	2017-18	2019-20
Total	29.8	3	9.9		
Total Inflation Adjusted	28.9	3	9.6		
11. Political and social systems, structures and processes					
Data Integration Partnership for Australia	6.8	3	2.3	2017-18	2019-20
Leading border Innovation	2.1	4	0.5	2013-14	2017-18
Design, Practice and Innovation Programme	15.3	3	5.1	2016-17	2018-19
Digitisation of payment process	562.9	4	140.7	2015-16	2018-19
myGov capacity development	51.6	6	8.6	2012-13	2017-18
Technology Innovation Centres	4.4	4	1.1	2015-16	2018-19
User Experience Centres	2.6	3	0.9	2016-17	2018-19
Innovation and Science Australia (ISA) Board	3.6	5	0.7	2015-16	2019-20
Investment Approaches to Welfare	36.8	5	7.4	2015-16	2019-20
National Disability Insurance Scheme Jobs and Market Fund	27.7	2	13.9	2018-19	2019-20
Reducing Pressure on Housing Affordability - Social Impact Investments	1.9	3	0.6	2017-18	2019-20
Social Impact Investing - building outcome measurement capacity	3.2	2	1.6	2018-19	2019-20
Social impact investing - homelessness partnerships	1.2	2	0.6	2018-19	2019-20
Social impact investing - priority group partnerships	2.3	2	1.2	2018-19	2019-20
Social Impact Investing - Sector Readiness Fund	5.3	3	1.8	2017-18	2019-20
Social Impact Investing - trial	3.5	2	1.7	2018-19	2019-20
Try, Test and Learn Fund	70.5	4	17.6	2016-17	2019-20
Total	801.6	8	100.2		
Total Inflation Adjusted	796.3	8	99.5		
13. General advancement of knowledge: R&D financed from other sources than GUF					
NMA - Cultural shared services centre	8.9	3	3.0	2017-18	2019-20
Questacon - Base Funding	107.6	11	9.8	2008-09	2019-20
Questacon - Engineering is Elementary - (Consolidated into Expanding Questacon's Education Outreach)	1.9	1	1.9	2019-20	2019-20
Questacon - Expanding The Questacon Science Circus In Regional Australia - (Consolidated into Expanding Questacon's Education Outreach)	2.6	1	2.6	2019-20	2019-20
Questacon - Inspiring All Australians in digital literacy and STEM	5.4	2	2.7	2018-19	2019-20
Questacon - Science Communications and Outreach Program	20.3	11	1.8	2009-10	2019-20
Social Impact Investing Market - trials	0.0	11	0.0		
Questacon - Science for Australia's Future (Inspiring Australia)	27.3	4	6.8	2015-15	2017-18
Questacon - Science: Inspiring Australia	17.9	3	6.0	2011-12	2013-14
Total	191.8	11	17.4		
Total Inflation Adjusted	199.7	11	18.2		
14. Defence					
Defence Innovation Hub funded through the Single Innovation Fund (includes DMTC and CTD) from Program 2.1 Strategic Policy and Intelligence	212.3	4	53.1	2015-16	2019-20
Total	212.3	4	53.1		
Total Inflation Adjusted	208.1	4	52.0		
Total	5,504.3	11	500.4		
IPI for GDP					
Inflation Adjusted	5,602.2	11	509.3		

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