UTS Innovation Roundtable

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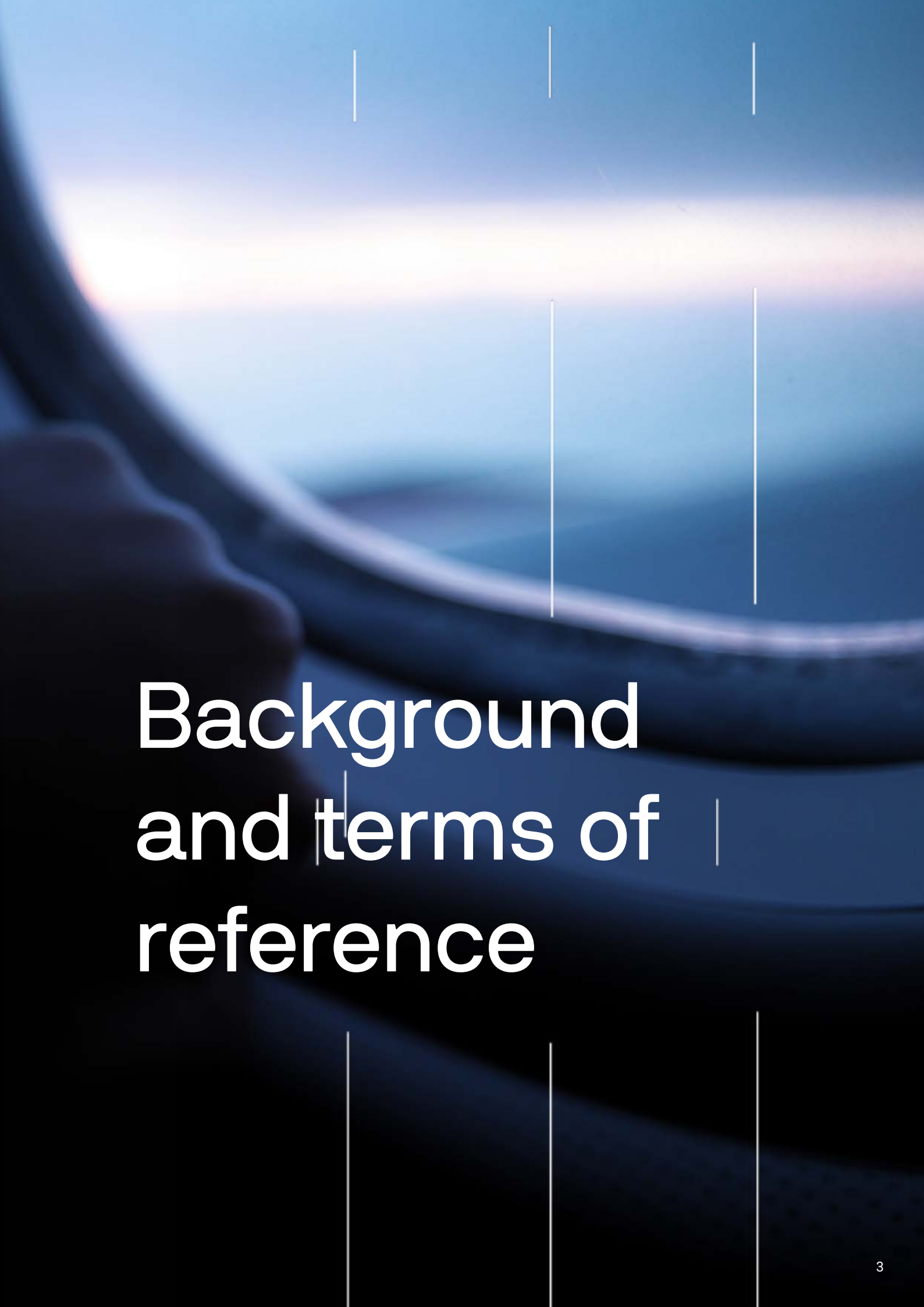


Background and terms of reference

Purpose

In the current Australian context, characterised by sustained and widespread disruption, there is an increasing gap between the needs of industry and society on the one hand and the ability of government to drive innovation through national policy and investment on the other. In response to this major challenge, the UTS Innovation Roundtable will convene innovation leaders representing the industries most impacted by anticipated technological and business model disruption and the national innovation policy stalemate. The UTS Innovation Roundtable will leverage the collective insights and expertise of its participants with a view to identifying specific opportunities for business-university collaboration that will result in quantifiable outcomes for Australian industry and tangible benefit for society.

Method

The UTS Innovation Roundtable will address a critical single thematic area each year, which will be determined by participants in the first gathering of the annual meeting cycle. UTS will provide the participants with a thorough economic and environmental scan of the state of innovation in Australia prior to the first gathering of the Roundtable, as well as a shortlist of the most urgent priority areas of both opportunity and risk. The outcome of the first meeting then will be a collective agreement on the thematic focus of the Roundtable for the year, the articulation of areas of collaboration, and the definition of specific outcomes and achievement milestones.

Agenda

Over the course of the calendar year, the UTS Innovation Roundtable will meet 1-2 times to progress Australia's innovation agenda. The first meeting will be about 'direct action on innovation' – how universities, industry and the community can work together to advance Australia's innovation agenda in the absence of a national innovation strategy.

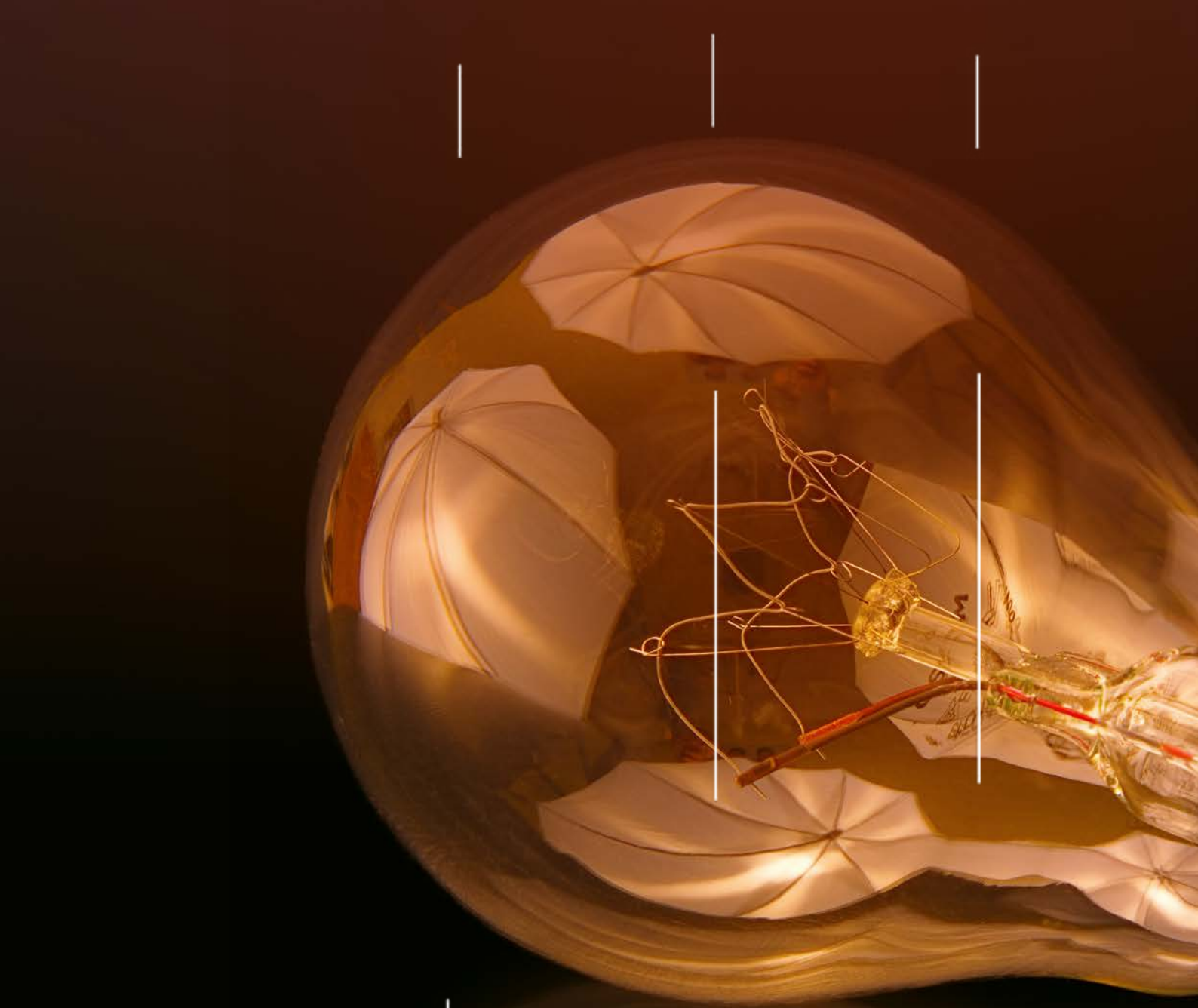
From this meeting, topics and challenges for further Roundtable discussions will be developed, and will wherever possible be informed by academic and business research. It is our expectation at these discussions that:

1. Background material will be provided by UTS on selected topics, including comparative research on international approaches together with ideas and hypotheses on the transformation of Australia's future prospects and performance
2. Outcomes will include specific and measurable initiatives and industry-university collaborations addressing key issues within the Roundtable theme, as well as clear and feasible action plans to ensure successful execution, delivery and evaluation of Roundtable projects
3. UTS will report to the Roundtable on the assessment and evaluation of progress with agreed initiatives, triage any blockages in their implementation and identify new or recalibrated priority project areas to ensure successful outcomes and broad impact
4. Meetings will often coincide with a public-facing event, intended to disseminate the outcomes of the Roundtable as well as to provide a forum for public engagement on the opportunities for creating a vibrant innovation economy and society in Australia.

Terms of Reference

The UTS Innovation Roundtable will contribute to Australia's economic transition to a more inclusive and dynamic knowledge-driven economy with Terms of Reference as follows:

- To identifying Australia's current and future areas of competitive advantage, and collaborative mechanisms for translating these into successful outcomes in global markets and value chains.
- To maximise the University's expertise in navigating technological transformation, creative thinking and skills development, as well as making innovation more tangible and impactful for Australian society.
- To provide a forum for national thought leadership in innovation and entrepreneurship, tackling economic, social and environmental challenges.
- To devise new approaches to industry and innovation policy that combine productivity-enhancing reform with an emphasis on social justice and the widest participation in the benefits of productivity growth.
- To create a source of ongoing advice and support for the University's own innovation and entrepreneurship strategy, encompassing entrepreneurship programs, precinct activities and external partnerships.



Agenda

UTS Innovation Roundtable – Agenda

4:00pm – 7:30pm
Wednesday 10 April 2019

UTS, Building 11, Faculty of Engineering & IT,
Level 12, Boardroom,
81 Broadway, Ultimo, NSW 2007

4.00pm – 4.20pm	Welcome & introductions
4.20pm – 4.50pm	Presentation of UTS paper: *Challenges for Australian Research & Innovation*
4.50pm – 5.40pm	Discussion: what business and universities can achieve together
5.40pm – 6.00pm	Wrap-up & next steps
6.00pm – 7.30pm	Light dinner
7.30pm	Close

Attendees

External

Adrian Turner	CSIRO's Data61
Andrew Charlton	AlphaBeta
Clare Harding	Deloitte
Dr Mark Cully	Department of Industry, Innovation and Science
Giam Swiegers	Former CEO of Aurecon
James Mabbott	KPMG Australia
Maria MacNamara	PORTAL Ideas
Martin Hoffman	Department of Finance, Services & Innovation
Martin Stewart-Weeks	Centre for Policy Development
Nicolas Grange	Retriever Communications
Pete Lead	Blue Chilli
Peter Poulet	Greater Sydney Commission
Pip Marlow	Suncorp
Prof Graham Wren	University of Strathclyde, Glasgow
Richard Webb	StartMesh

UTS

Prof. Attila Brungs	Vice-Chancellor
Prof. Glenn Wightwick	Deputy Vice-Chancellor (Innovation & Enterprise)
Prof. Roy Green	Chair UTS Innovation Roundtable
Prof. Ian Burnett	Dean, Faculty of Engineering & Information Technology
Dr. John H Howard	Adjunct Professor
Angelika Nadler	Executive Officer DVCIE

Apologies

Andrew Stevens	Innovation and Science Australia
Angus Armour	Australian Institute of Company Directors
Annie Parker	Microsoft
David Thodey	CSIRO/ Jobs for NSW
Dig Howitt	Cochlear Ltd
Mary Brittain-White	Retriever Communications
Maureen Dougherty	Boeing
Petra Andren	Cicada Innovations
Prof. Alan Hughes	University of Cambridge
Prof. Christos Pitelis	Brunel University London
Seb Eckersley-Martin	Blue Chilli
Tim Reed	MYOB
Topaz Conway	Cicada Innovations

Background paper

2019

Challenges for Australian Research & Innovation

BACKGROUND PAPER FOR UTS INNOVATION ROUNDTABLE
APRIL 10 2019

JOHN H HOWARD & ROY GREEN
UNIVERSITY OF TECHNOLOGY SYDNEY

Key Points

- *Australia's post mining boom transition requires investment in research and innovation. However, both government and business expenditure in these areas has declined in recent years with little prospect of significant improvement, at least on the part of government*
- *By contrast, university expenditure on research and innovation has increased, but is sourced precariously in student fees and funding. The data suggest there is also a mismatch between the priorities of this research expenditure and the interests of Australian industry*
- *Government policy at national level has been characterised by program gaps and discontinuities over a considerable period. Apart from the Cooperative Research Centre program, there is no consistent policy framework to drive collaboration between business and universities*
- *Even where business and universities have a shared interest in collaboration, it is often the case that the terms of engagement are not sufficiently clear or attractive, notwithstanding some impressive examples of successful long-term partnerships particularly at local level*
- *The challenge is to understand the barriers to and the opportunities for productive collaboration irrespective of government policy, including the role of universities in building innovation capability and performance for both existing firms and high potential startups.*

1 Context: the policy setting

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, economic commentators and innovation analysts would argue that continued success is very far from assured.

The question for us in a post mining boom context is, "How to transition to new sources of growth as commodity prices and investments in resources projects normalise" (Green & Howard, 2015a, 2015b; Green et al., 2012; Lydon et al., 2014). But the question has not taken on the urgency that might be expected.

In 2018, Australia's exports of goods and services amounted to US$253.8 billion, representing 21.5% of GDP. Although total exports have increased by only 0.5% since 2014, they increased by 10.5% between 2017 and 2018. This growth has been concentrated in resource commodity exports.

Exports of resource commodities have shown remarkable resilience. The highest dollar value of Australia's top 10 export categories during 2018, together with the percentage share in total exports from Australia is listed below[1]. Over two thirds of exports are in commodity categories.

Export Category	$US billion	Per cent of total exports
Mineral fuels including oil	87.7	34.6%
Ores, slag, ash	59.7	23.5%
Gems, precious metals	16.1	6.3%
Meat	10.2	4.0%
Inorganic chemicals	8.2	3.2%
Cereal	4.9	1.9%
Machinery including computers	4.8	1.9%
Aluminium	3.8	1.5%
Electrical machinery, equipment	3.2	1.3%
Optical, technical, medical apparatus	3.2	1.3%

Exports of manufactured items (machinery and optical, technical and medical devices) amounted to $US11.2 billion, or only 4.5% of the total, though these categories did also experience significant growth over the 2017-18 period.

The question about transition still remains -

- 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 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.

[1] http://www.worldstopexports.com/australias-top-10-exports/

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.

It has long been argued that growth will not come automatically to Australia and we must make the effort to change. Just over 20 years ago David Mortimer issued his report *Going for Growth* (Australia. Review of Business Programs, 1997)[2] 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.

The themes and priorities urged on policy-makers at that time have been repeated in "libraries" of policy papers, reports, and Ministerial statements ever since. These are becoming "glossier", with less substantive content and an absence of clear new commitments. Many are simply a restatement of previous positions. Perhaps the impact is expected in the announcement, with its attendant media profiling, rather than achieving any planned 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 *export and global markets*. The "disruption" that occurred with the removal of tariff protections in the 1980s and 90s was, in retrospect, not managed as well as it could have been – at the firm, industry or policy levels.

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 history 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 and mining technologies thrived in the global context. In line with Christensen's disruption concept (Christensen, 1997), new entrants have embraced the opportunities and have grown 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.

Innovation and industrial policy has reflected an ongoing tension between proponents of activist national and sector based strategies on the one hand and public service economists who have eschewed any idea of "picking winners" on the other. There is still a very strong view within the Australian Government that innovation and industrial policy should be principally confined to cases of "market failure".

However, international research has more recently been concerned with "system failure", denoting a failure of key institutions in the innovation system to interact effectively (Dodgson et al., 2010). In Australia, *there has been a reluctance to invest in building capacity and capability for business, university and government institutions to engage efficiently and effectively*. The CRC Program is really the only serious and successful long-standing commitment in this area.

Innovation policies and programs, with the notable exception of the R&D Tax Incentive and CRC Program, have been short term in nature (mostly 3-4 years), oriented around "funding" (albeit with very modest amounts of money), categorically defined, application and submission driven, rules based, and subject to

[2] 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*.

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 (Best, 2018; Mazzucato, 2015).

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.

An enduring consequence has been that Australian businesses are still regarded as poor innovators and entrepreneurs. 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.

A further attempt was *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 a number of challenges[3]:

- 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 will come from knowledge intensive companies that innovate and export, as they are the most profitable, competitive and productive.

Innovation and Science Australia (ISA) anticipated that such businesses will 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[4], and above all, stronger links between business and the national research and education system.

The problem, however, 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. This paper addresses a number of potential reasons for this problem:

- Differing institutional settings and drivers between universities, business, and government
- A possible mismatch in priorities between university investment in research and those of business
- Declining levels of government and business investment in research and innovation
- Different institutional settings and priorities between universities, business and government.

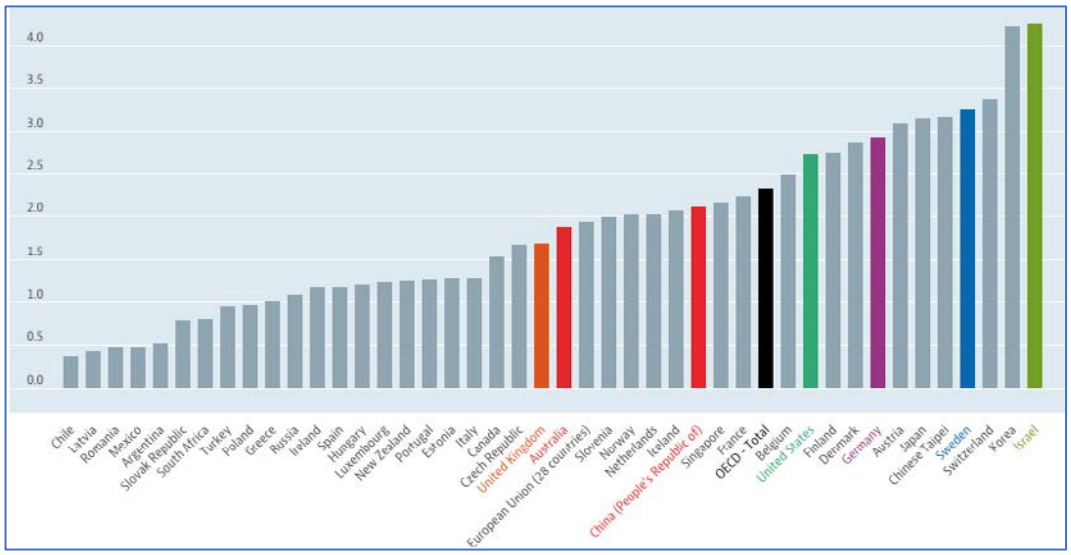
2 What Australia invests in research and development

Australia ranks poorly in terms of expenditure on R&D, amounting to a reported 1.88% of GDP, compared to the OECD average or 2.03 per cent, 2.11% for China, 2.74% for the US, and a massive 4.25% for Israel. A summary chart is in Figure 1.

[3]These themes were of course addressed in 2001 and 2004 in the two *Backing Australia's Ability* Strategies (Australia. Prime Minister, 2001, 2004), in 2008 in *Venturous Australia* (Australia. Review of the National Innovation System (Cutler Review), 2008), *Powering Ideas* (Australia. Minister for Innovation Industry Science and Research, 2009), the *Asia in the Asian Century White Paper* (Prime Minister, 2012) the *Rural Research and Development Policy Statement* (Australia. Minister for Agriculture Fisheries and Forestry, 2012), the *Industry Innovation and Competitiveness Agenda* (Australia. Minister for Industry and Science, 2014), the *Agricultural Competitiveness White Paper* (Australia. Minister for Agriculture, 2015), and the *National Innovation and Science* Agenda (Australian Government, 2015)

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

Figure 1: Gross Expenditure on R&D – Australia and the OCED



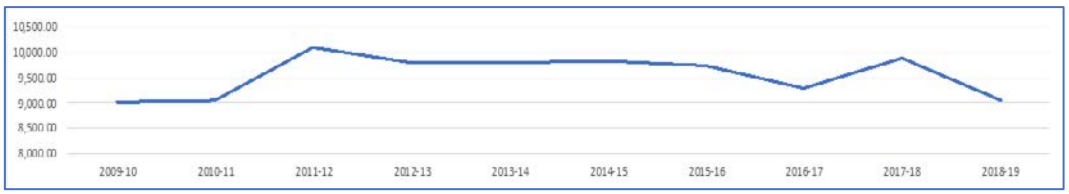
Source: https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm

In 2010 Australian R&D expenditure as a proportion of GDP was significantly higher at 2.19 per cent. A major explanation for the 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 decline. The long-term trend is indicated in Figure 2.

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 2016-17 with the commitment to the Renewable Energy Agency, but has since fallen.

Figure 2: Commonwealth support for R&D – Inflation Adjusted - 2009-10 - 2018-19 ($'000)

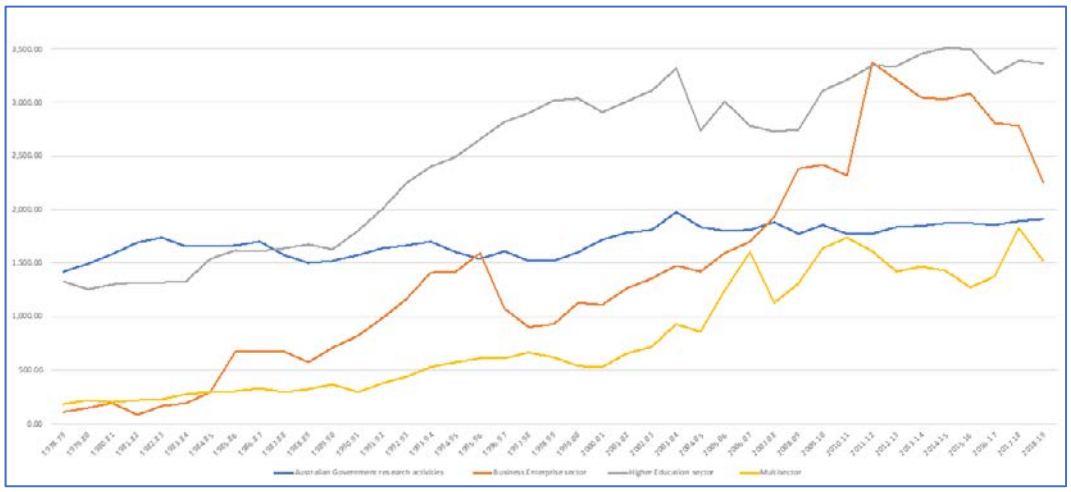


Source: Commonwealth of Australia, Science, *Research and Innovation Budget Tables, 2018-19*. Inflation adjusted by applying the GDP deflator, included in the Table documentation.

Information on Commonwealth support for R&D across sectors over the over the period 1978-79 to 2018-19 is provided in Figure 3 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 very little significant 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 3: Commonwealth support for R&D - Inflation Adjusted 2009-10 - 2018-19 – Major Categories ($'000)



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

Expenditure under the major Commonwealth R&D assistance programs over the period 2009-10 to 2018-19, are represented in Figure 4. Together these programs are expected to make up 77.5% of total Commonwealth assistance in 2018-18.

Figure 4: Commonwealth support for R&D – Major Programs (Inflation Adjusted) - 2009-10 to 2018-19

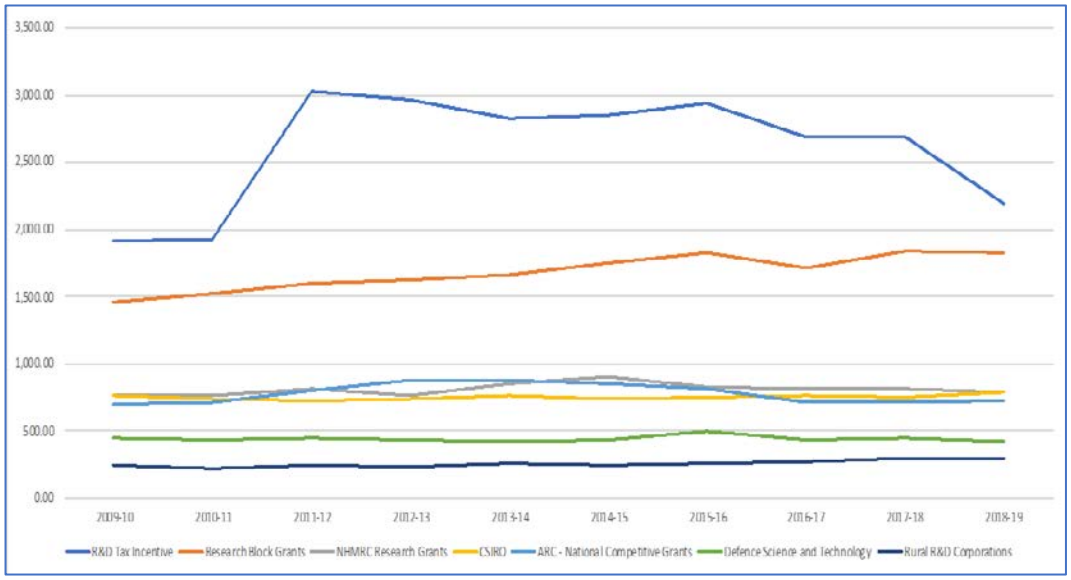


Figure 4 points to the continuing significance of the R&D Tax incentive, which has been declining since 2011-12, and growth in the Higher Education block grants. Other programs have not changed substantially over the time period.

These changes and fluctuations in support for research over the 20-year period reflect major discontinuities in Commonwealth research and innovation policy. This is addressed in Section 6 below. But by way of introduction, it is instructive to look at how Australia allocates its research effort.

3 How we allocate our investment

The Clarivate InCites (Thompson Reuters) *Web of Science* database indicates that Australia's research effort is heavily concentrated in medical and health research. Over 20 years Australian medical research output increased from 10,356 Web of Science documents in 1999 to 36,792 in 2018 (having peaked at 37,961 in 2016) - a 3.5-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 5.

Figure 5: Web of Science Documents, Australia trend 1999-2018

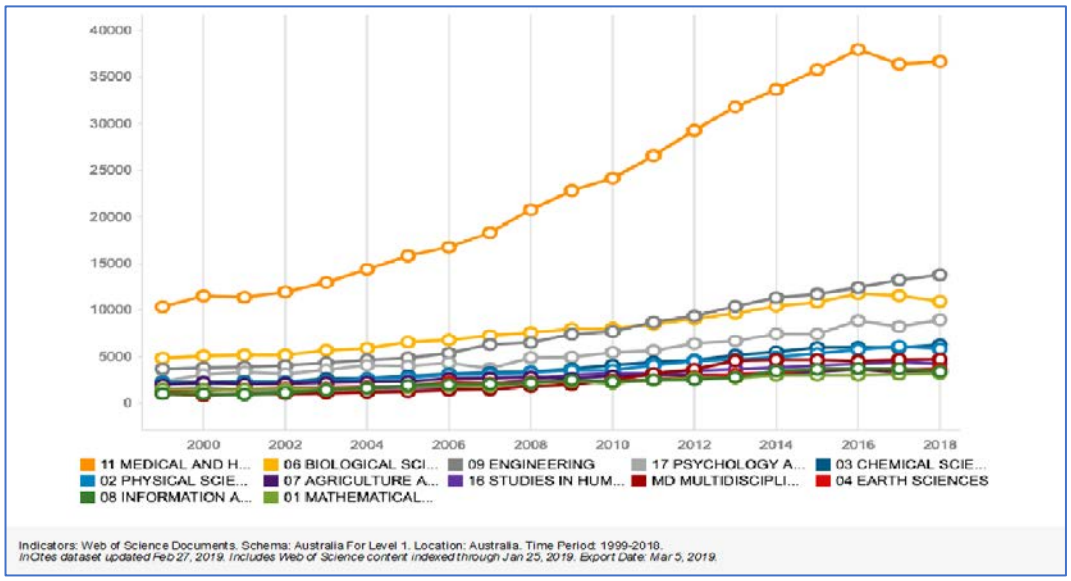
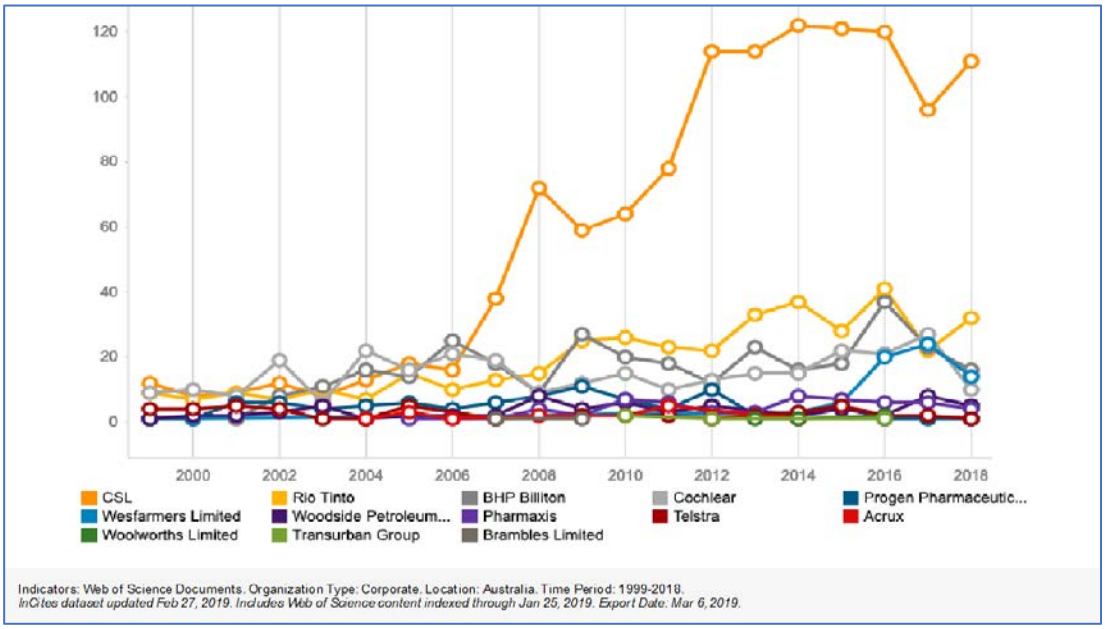


Figure 5 also indicates that research output in Engineering, the second highest output category, increased from 3,701 documents in 1999 to 13,789 in 2018 (a 3.7-fold increase). Biological sciences output increased from 4,837 to 10,960, and Psychology from 2,359 to 8,958. Output is dominated by the Go8 universities and medical research institutes. Further information and analysis is 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 13 companies. This is captured in Figure 6 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 6 of course or foreign owned corporations that operate in Australia.

Figure 6: Web of Science Research Documents - Australian Companies 1999-2018



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).

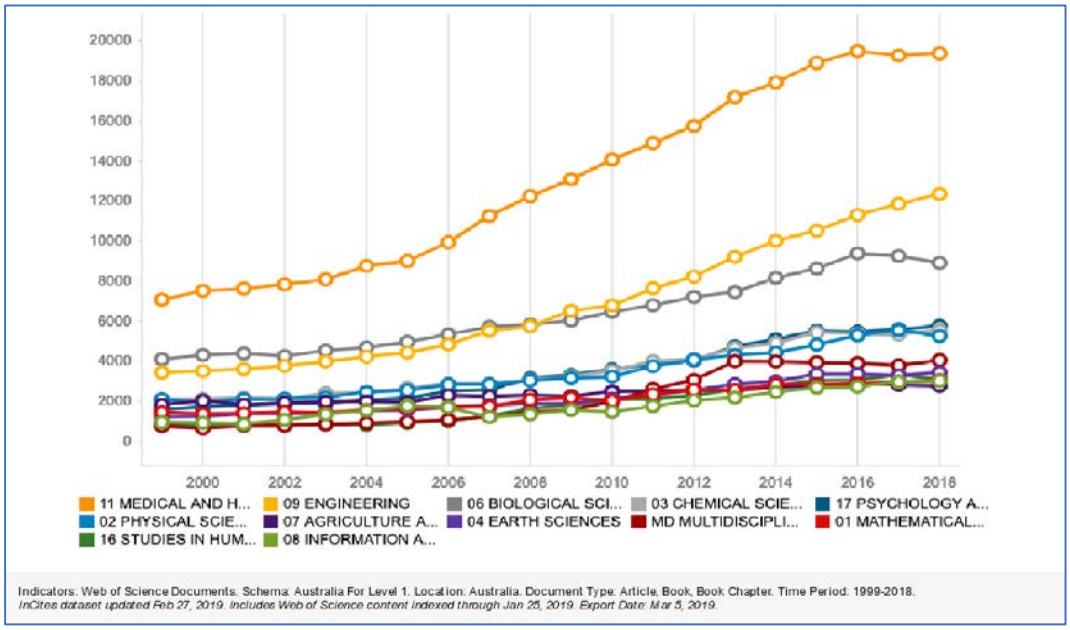
The protection regime embodied in Australian industry policy until quite recently would suggest that collaboration between universities and industry has not been part of an Australian industrial research DNA.

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[5]. 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.

Innovation systems thinking that emerged in the 1990s added to the awareness of the potential for better university-business connections. But building those connections in a sustainable way has been a slow process, and the institutional relationships between industry and universities are still not as strong as they might be[6].

The research output trends reported in Figure 5 for all *Web of Science* output are very similar for more scholarly output of articles, books and book chapters, as indicated in Figure 7, 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 7.

Figure 7: Web of Science Documents, Australia, trend 1999-2018 (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 2 in Attachment 2, which shows that output has increased by 200% over the 20 years from 1999 to 2018. 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 interest in the digital economy and digital transformation context. However, the increase has been substantial over the period – and 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.

[5] 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.
[6] See AIRG Paper

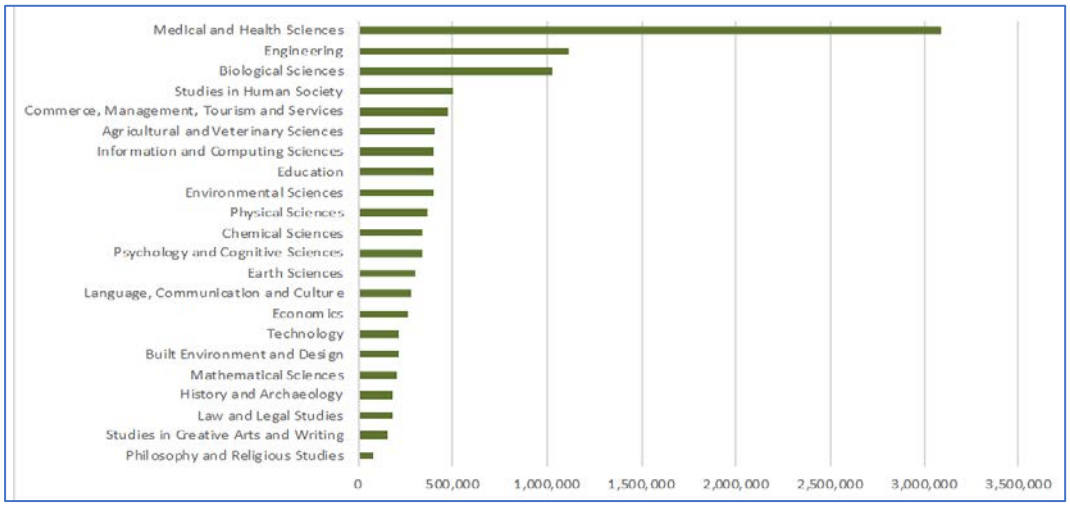
Australia's commitment to Medical research is long standing, well known and highly regarded within the community. It is strongly supported by governments (Commonwealth and State/Territory)[7], philanthropic donations and bequests, commercial income, and universities themselves. Most of Australia's medical 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 8 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 8: Higher education expenditure on R&D by Fields of Research, 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.

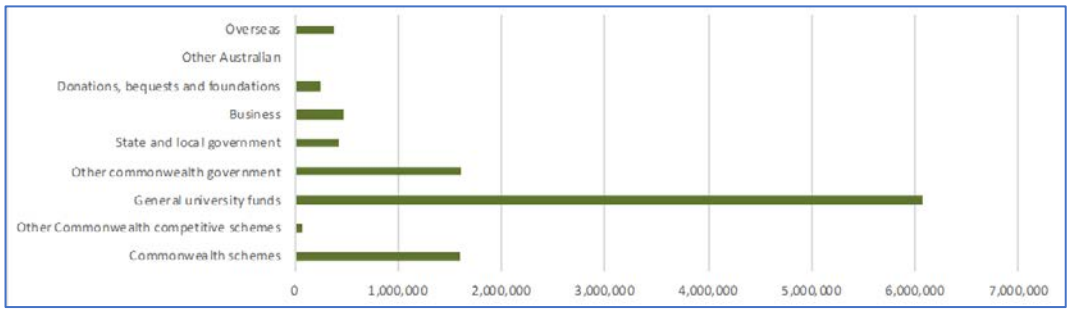
Moreover, as medical research also attracts high citation and indexing in prestigious journals, feeding into global university rankings, universities may be motivated to allocate a greater proportion of internal resources to the Field. Anecdotal evidence suggests that a significant proportion of internal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

Figure 9 shows the sources of funds for Higher Education Expenditure in R&D for 2016. By far the largest proportion comes from general university funds[8].

[7] 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.

[8] 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 9: 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 "startups" and premature "commercialisation" – although blockbusters do happen[9].

4 An industry-higher education mismatch?

In the *2017 Innovation System Report*, the Commonwealth Office of the Chief Economist reported that higher education expenditure 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 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. There is now greater support through the research block grants scheme, which potentially gives universities greater flexibility.

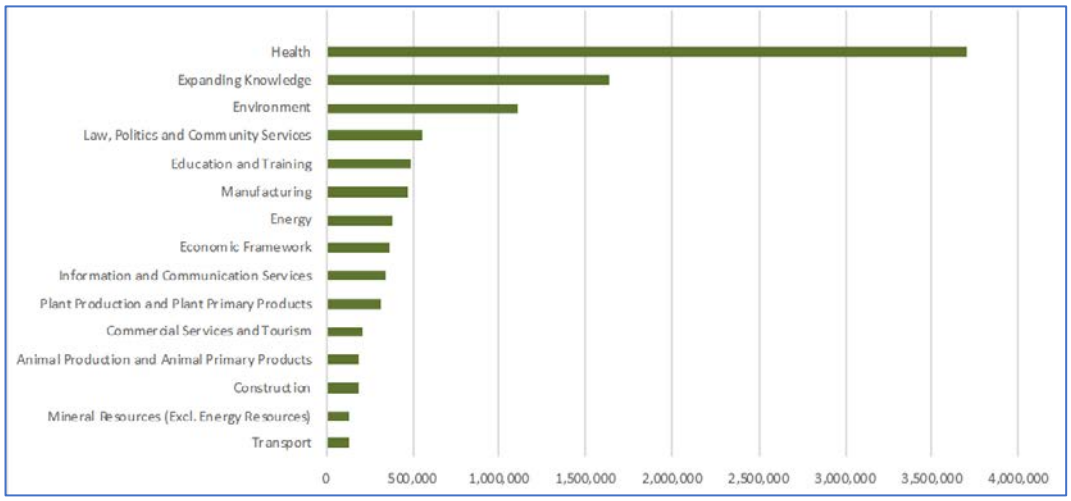
By comparison, Government expenditure on R&D stood at 0.21% of GDP in 2014, having *declined* from 0.27% in 2010, and 0.37% in 1995. This placed Australia *20th* among OECD countries. Perhaps alarmingly, Australia ranks highly in terms of the proportion of Government R&D financed by industry – 9.9% in 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.

Universities are keen to increase their commitment to industrial innovation through collaboration. But, as discussed elsewhere[10] there must be a change in the *culture of the relationship* from one of "research provider", reflected in Government metrics around research 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.

It is often said that there is a "mismatch" between university research priorities and industry requirements. To start off with, information on university research, according to socio economic objective, is provided in Figure 10. The data again points to a substantial commitment of research investment to Health, Expanding knowledge (discovery), and Environment but comparatively less to Manufacturing, Energy, Information and communication services, Agriculture, Construction and Mining.

[9] The Bio21 Project in Parkville, Melbourne commenced on a tenuous basis 20 years ago and has developed into a robust, globally focused capability.
[10] See recent presentation for Australian Innovation Research Group, February 2019

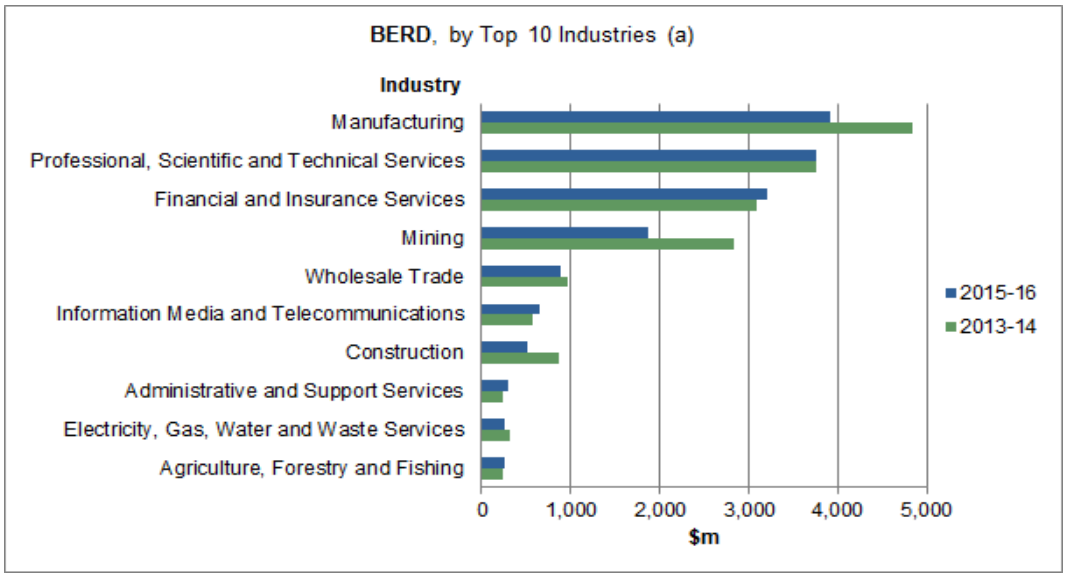
Figure 10: Higher Education Expenditure on R&D, by Socio Economic Objective, 2016



Source: ABS

In contrast to university research expenditure commitment, *business expenditure on R&D gives a high priority to* Manufacturing, Services, and Mining – and much less in other industry areas. This is indicated in Figure 11.

Figure 11: Business expenditure on R&D by Socioeconomic objective, Australia, 2015-16

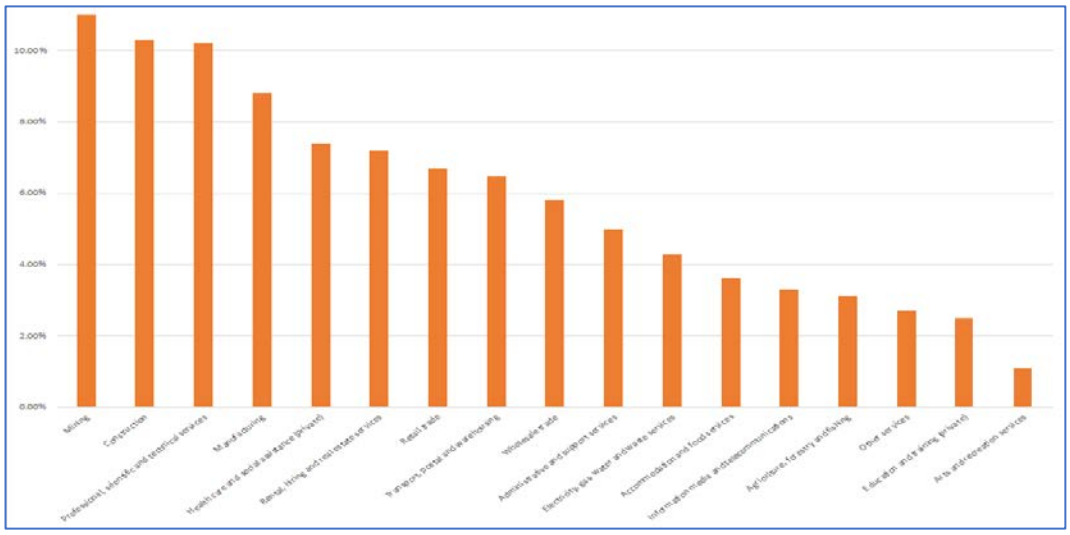


Source: ABS

These differences are also highlighted when looking at the structure of Australian industry, in terms of proportions of industry value added, as summarised in Figure 12. The largest industry sectors – mining, construction, professional, scientific and technical services and manufacturing – account for just over 40% of Australian industry value added. With the exception of Mining and Construction, the largest industries undertake the highest levels of research. These industries would potentially call for research in fields such as Engineering, Mathematics and Chemistry together with research into Information and computing (AI, computation theory, software, data and information systems). But these industry research areas are not reflected strongly in the research effort within universities.

What businesses want and what universities do, and where government provides support, and complements other capability, is a complex decision and resource allocation process.

Figure 12: Australian Industry Value Added 2016-17 (% of Total)



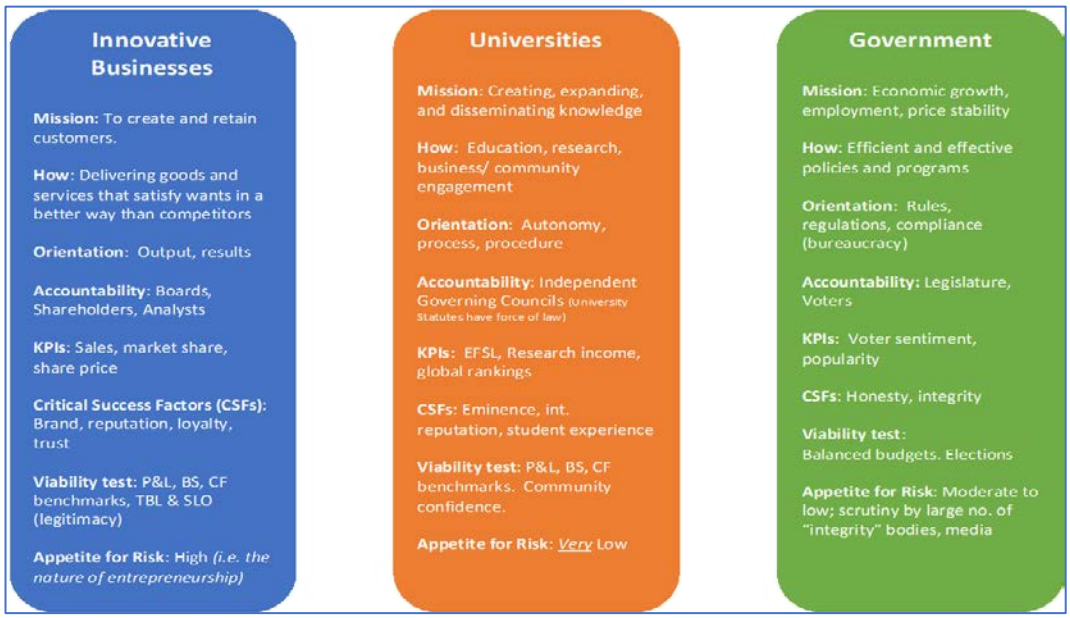
Source: ABS

It is a much more complex process than matching Fields of Research. What is often missing, however, are relationships that develop mutual understanding of research capability and business requirements. Developing these relationships takes time, energy, commitment and resources. It has a focus on business development rather than generating research income (sales).

Unless university research is funded, either publicly or privately, there is little incentive to commit to it. 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, funding arrangements that are short term and with levels of program/project assistance often too small to make a real difference.

The relationships between universities, industry and government are sometimes visualised through the "Triple Helix" depicted in *Universities and the global knowledge economy: a triple helix of university-industry-government relations* (Etzkowitz & Leydesdorff, 1997). This concept is based on a perception of a logical connection and convergence of missions between the three main societal pillars,[11] and it has attracted a following among consultants and policy analysts[12]. The characteristics of each pillar and their principal drivers are set out in Figure 13.

Figure 13: Business, Universities, Government: Different Characteristics and Drivers



[11] Sometimes a fourth pillar is added covering NGOs, the Established Church, and Charities.
[12] See https://www.triplehelixassociation.org/

However, actually achieving effective and value creating relationships is much more challenging. *There is no inherent or natural tendency for the fundamental missions and purposes of each pillar to converge*. Nor are there are obvious imperatives or "burning platforms" driving convergence in Australia, given our recent record of uninterrupted growth, only general concerns about our transition to a more competitive and dynamic knowledge-based economy.

Significantly, 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. 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 national or local level, a Triple Helix approach 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 Policy gaps and discontinuities

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 buckets".

The effect has been that national innovation and industry 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[13], 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.

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[14].

At the risk of being too disparaging, it would appear that a stage has been reached where public support for innovation and industry development has evolved into a game 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"[15].

In a context of declining public support for 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. The attention given to analysis and measurement perhaps reflects an endeavour to demonstrate that the Australian innovation picture might not as bad as international comparisons might show. So far, metrics frameworks have not been able to come up with any meaningful measures of collaboration.[16]

An underlying problem is that the Australian approach has never addressed the governance, management, and organisational aspects of innovation strategy or performance. 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, 1994) and the profession of management is highly regarded (Drucker, 1993, 1994). There have only been a few Australian contributions in this context, though interest may be increasing (Carnegie et al., 1993; Dodgson et al., 2015; Dodgson et al., 2008; Green, 2013; Green et al., 2009; Karpin, 1995; Samson, 2010).

[13] Inevitably to be spread "equitably" across States and Territories and electorates.
[14] 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.
[15] 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.
[16] 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.

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 to advise 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.

It might be argued that a "sector" approach to innovation and industry strategy is emerging in separate policy domains under the responsibility of different Ministers and Portfolios – Defence, Health, Mining, Energy, Agriculture (farming), Treasury, for example[17]. However, this approach fails to address strategies for critical *enabling* innovation technologies and capabilities – such as Information systems and computing, engineering, and the creative industries. Like Design and the Creative Industries, Information Systems and computing policy has fallen between the cracks in Ministerial Portfolio responsibilities since the Goldsworthy Report of 1997 (Australia. Information Industries Taskforce, 1997).

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. After all, universities are State owned public organisations.

An example where the States and universities are collaborating is provided by the recent announcement by the NSW Government of the establishment of a Sydney Quantum Academy (SQA) to be jointly developed with the University of Sydney, UNSW, UTS and Macquarie University.[18] 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; and
- 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.

6 Rethinking collaboration

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 (Charles et al., 2012; OECD, 2012, 2013). Smart Specialisation is embedded in the current EU Cohesion Strategy (McCann & 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 & 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, with the objective of supporting 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*

[17] As indicated to some extent with the Growth Centres Program.
[18] See https://www.finance.nsw.gov.au/about-us/media-releases/sydney-quantum-academy-create-jobs-future

(The Sydney Innovation and Technology Precinct Panel, 2018). The Greater Sydney Commission is supporting the formation of health and education precincts[19].

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 helping to spot new business opportunities and in driving down the investment risks faced when innovating (Matthews & Lacy, 2017). 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, 2015, 2017).

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 & 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 and emerged as key players in support of the development of regional and local innovation ecosystems in the cities and regions where they are located. Universities 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 is a consortium to develop the Melbourne Connect precinct. The University of

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

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[20]. 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.

7 What works?

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 *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.

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 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 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. There were several initiatives in Australia established with State Government investment (particularly Victoria and Queensland).

The US URC framework has become 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. They have modified the single discipline approach to research and training and focussed on multi-disciplinary research that better suited 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".[21] This often takes the form of university-industry cooperative research

[20] The University of Wollongong has a long history of collaboration with BlueScope Steel, which is outlined in Attachment 1.
[21] See https://www.arc.gov.au/engagement-and-impact-assessment

centres. The CRC Program has produced a small number of enduring research centres – that outlasted the government funding. However, 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[22]. 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".[23] This would appear to have a stronger chance of achieving critical mass and longevity.

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 a host university. 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 challenge.

[22] 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.
[23] See https://www.csiro.au/en/News/News-releases/2018/Sixth-Wave-Alliance-to-accelerate--Robotics-and-Autonomous-systems-RandD

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.

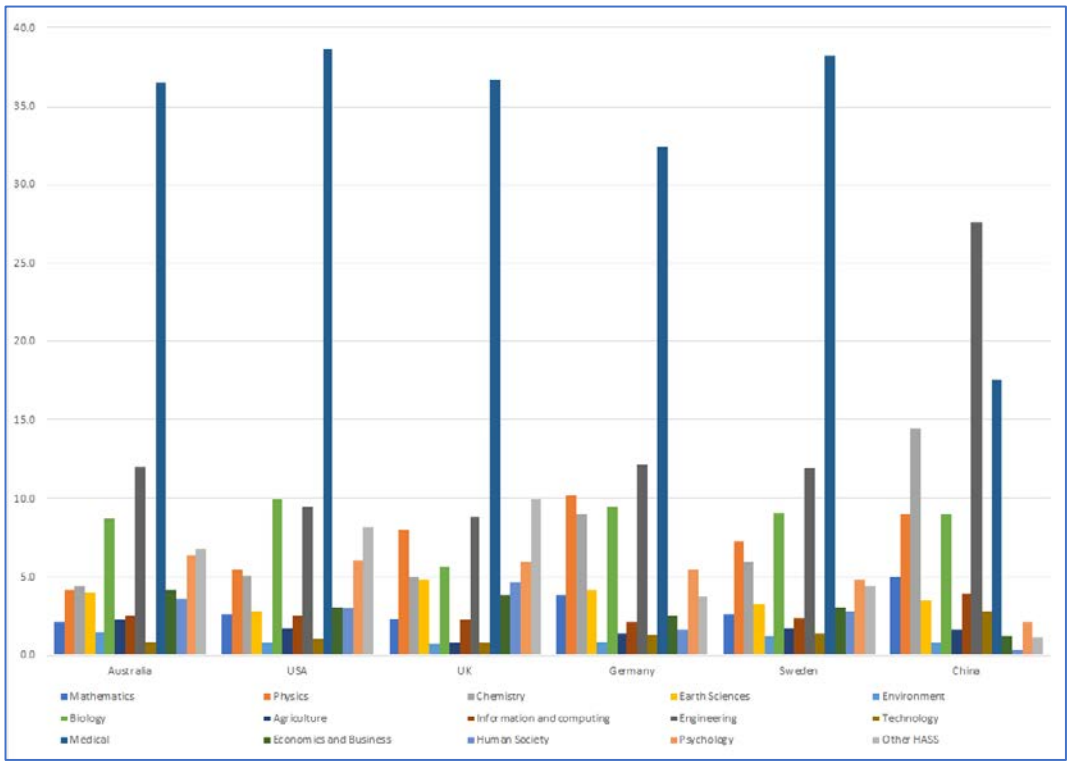
- Two autonomous grit-blasting robots now in service with grit-blasting crew at the Sydney Harbour Bridge.
- UTS Start-up "SABRE Autonomous Solutions".
- Smart hoist for patient handling.
- Bio-inspired autonomous climbing robot deployed for underwater inspection of the Sydney Harbour Bridge

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

Attachment 2: Additional Tables and Charts

The proportion of these countries' research output across major Research fields is contained in Figure 14 in Attachment A.

Figure 14: Proportion of Countries' Research Investment Allocated to Specific Fields of Research



The data behind Figure 1 is in **Error! Not a valid bookmark self-reference.** below.

Table 1: 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 2: Increase in Research output 1999-2018 across Fields of Research

Name	Rank 2018	Web of Science Documents 2018	Proportion 2018	Web of Science Documents 1999	Proportion 1999	Increase 1999-2018 (No.)	Increase 1999-2018 (%)
01 Mathematical Sciences	11	3,048	3.3%	1,436	4.7%	1,612	112.3%
02 Physical Sciences	6	5,259	5.7%	2,087	6.8%	**3,172**	152.0%
03 Chemical Sciences	5	5,554	6.1%	2,019	6.6%	**3,535**	175.1%
04 Earth Sciences	8	3,442	3.8%	1,210	4.0%	**2,232**	184.5%
05 Environmental Sciences	9	3,198	3.5%	1,005	3.3%	**2,193**	218.2%
06 Biological Sciences	3	8,907	9.7%	4,090	13.4%	**4,817**	117.8%
07 Agriculture and Veterinary	13	2,769	3.0%	1,815	5.9%	954	52.6%
08 Information and Computing	12	3,019	3.3%	347	1.1%	**2,672**	770.0%
09 Engineering	2	12,346	13.5%	3,434	11.3%	**8,912**	259.5%
10 Technology	17	1,396	1.5%	403	1.3%	993	246.4%
11 Medical and Health Sciences	1	19,374	21.2%	7,068	23.2%	**12,306**	174.1%
12 Built Environment and Design	18	1,283	1.4%	127	0.4%	1,156	910.2%
13 Education	15	1,795	2.0%	313	1.0%	1,482	473.5%
14 Economics	16	1,675	1.8%	548	1.8%	1,127	205.7%
15 Commerce, Management, Tourism	14	2,514	2.7%	437	1.4%	**2,077**	475.3%
16 Studies In Human Society	10	3,110	3.4%	822	2.7%	**2,288**	278.3%
17 Psychology and Cognitive Sciences	4	5,758	6.3%	1,597	5.2%	**4,161**	260.6%
18 Law and Legal Studies	22	480	0.5%	66	0.2%	414	627.3%
19 Studies in Creative Arts, Writing	23	444	0.5%	110	0.4%	334	303.6%
20 Language, Communication Culture	19	989	1.1%	303	1.0%	686	226.4%
21 History and Archaeology	21	548	0.6%	294	1.0%	254	86.4%
22 Philosophy and Religious Studies	20	580	0.6%	210	0.7%	370	176.2%
Md Multidisciplinary	7	4,048	4.4%	771	2.5%	**3,277**	425.0%
		91,536	100.0%	30,512	100.0%	61,024	200.0%

Table 3: 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 per cent, 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, 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, 1996a, 1996b).

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 & 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'[24] 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.

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

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, ie 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.

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[25]. The Government responded that it would implement most the Review's recommendations. The Government commented in its response[26]:

- 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

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

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.

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*[27].

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.

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

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