South Australian Productivity Commission

Final Report

Research and Development Inquiry

18 January 2021

Government of South Australia

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South Australian Productivity Commission
GPO Box 2343
Adelaide South Australia 5001
AUSTRALIA

Telephone: 08 8226 7828
Email: sapc@sa.gov.au
Website: www.sapc.sa.gov.au

An appropriate citation for this publication is:

South Australian Productivity Commission, *Research and Development Inquiry*, Final Report, January (2021).

About the South Australian Productivity Commission

The Commission provides the South Australian Government with independent advice on facilitating productivity growth, unlocking new economic opportunities, supporting job creation and removing existing regulatory barriers.

Premier and Cabinet Circular PC046 sets out the objectives and functions of the Commission; how inquiries are referred to the Commission, undertaken and reported on; and how the Commission and public sector agencies work together.

The Commission was established to assist the government to:

- improve the rate of economic growth and the productivity of the South Australian economy in order to achieve higher living standards for South Australians;
- improve the accessibility, efficiency and quality of services delivered or funded by government;
- improve South Australia's competitiveness for private sector investment;
- reduce the cost of regulation;
- facilitate structural economic changes while minimising the social and economic hardship that may result from those changes;
- take into account the interests of industries, employees, consumers and the community;
- increase employment;
- promote regional development; and
- develop South Australia in a way that is ecologically sustainable.

The Commission is supported by the Office of the South Australian Productivity Commission (OSAPC) which is an attached office of the Department of the Premier and Cabinet. The Chair of the Commission also serves as the Chief Executive of the OSAPC.

For more information on the Commission, including circular PC046, visit the website at www.sapc.sa.gov.au.

Disclosure

The Commissioners have declared to the South Australian Government all personal interests that could have a bearing on current and future work. The Commissioners confirm their belief that they have no personal conflicts in regard to this inquiry.

Terms of Reference

SOUTH AUSTRALIAN PRODUCTIVITY COMMISSION INQUIRY INTO RESEARCH AND DEVELOPMENT

I, Steven Marshall, Premier, hereby request that the South Australian Productivity Commission (the Commission) undertake an inquiry into research and development.

Background

The South Australian Government has the goal of raising South Australia's rate of economic growth.

The relationship between research and development (R&D), innovation and economic growth has attracted considerable attention from economists and policy-makers. An understanding of R&D activity in South Australia and how it translates into economic performance are extremely important to lifting productivity, incomes and employment in the South Australian economy.

Recent statistics suggest that South Australia's share of national R&D activity has been shrinking. According to the ABS:

- Business expenditure on R&D (BERD) has been relatively static in South Australia over the ten years to 2015-16 with SA's share of national BERD falling from a high of 5.8 per cent in 2011-12 to 4.6 per cent in 2015-16
- Higher education expenditure on R&D (HERD) grew more slowly in South Australia than the national average between 2006 and 2016, with SA's share of Australian HERD falling from 7.3 to 6.5 per cent.

Intellectual Property Australia data indicates that the number of patent applications filed in South Australia has fallen 12 per cent between 2011 and 2017.

Terms of Reference

An inquiry by the SA Productivity Commission would examine trends in R&D and the factors which influence the extent to which this R&D translates into growth in South Australia. The key thrust is to understand how the current structure and operation of the state's public and private R&D contributes to long-term productivity gains and economic growth and make recommendations on actions to raise that contribution.

Independent advice on SA's R&D performance and associated policies and recommendations on reforms to lift the State's R&D performance will help to inform development and delivery of the government's Growth State initiative.

The scope of this inquiry includes mining, agribusiness, cyber risk and other areas as appropriate, except health and medical research which is being considered separately. The Commission is to apply insights from that separate stream to inform this inquiry where relevant.

While wide-ranging data on R&D and innovation is available nationally, comparatively little data is available at the state level. The Commission is to work with government agencies, universities, research institutions and industry to develop indicators and data sets which can be used to monitor and explain the state's performance and inform government policy.

South Australia's Chief Scientist and the Department of Innovation and Skills have been charged with developing strategies to lift innovation performance. The Commission is to have regard to this work where relevant to this inquiry.

The inquiry would examine: the role and settings of policy levers available to the state government; the effectiveness of various government interventions aiming at increasing R&D efficiency and outputs; and recommend actions the government can take (including advice to the Australian Government) on those matters.

Scope

The Commission is asked to consider and report on R&D activity in South Australia: how it translates into economic performance and wellbeing in the State; and recommend actions that the South Australian Government might take in connection with South Australian based R&D to:

1) Increase the output and productivity of South Australian-based publicly funded R&D;
2) Increase South Australian based private sector R&D, and in so doing;
3) Increase the state's:
   a) share of Australian Government funding for research; and
   b) rate of economic growth.

These recommendations are to be based on an evidence-based review of the state's R&D policies, activities and performance including the identification and assessment of:

1) Performance measures
   a) measures of the output and productivity of research activity by (including by key areas of research), and the performance of, publicly funded research institutions in South Australia compared to other jurisdictions.
2) Drivers of output and productivity of SA based R&D
   a) funding
      i) an important task is to identify the extent of funding for research in South Australia (public and private, state and federal, national and international), by source and area of application, as well as forms of expenditure (e.g. capital and operating).
   b) other key factors including
      i) talent pools and the capacity to attract new talent
      ii) industry structure and composition
      iii) hard infrastructure
      iv) the demography of the state
      v) access to data and efficiency of collection and acquisition and other relevant matters, in the context of the changes in the technology of research methods
      vi) national R&D and innovation policies and programs.
3) Current and prospective collaborations
   a) existing collaboration on research between research organisations (public and private) and linkages between those organisations and industry, as well as new models for collaboration.
4) Current and prospective industry engagement
   a) demand for, and current barriers to undertaking, research in cooperation with industry in South Australia and new models to improve industry experience and drive private sector research.

In its consideration of the above matters, the Commission is expected to have regard to the South Australian Government's Growth State initiative and relevant state and national policies including their performance.

Inquiry Process

The Commission will consult with the SA Chief Scientist, SA agencies, universities, research institutions, industry, relevant peak bodies and other key stakeholders during the inquiry.

The Commission may second and/or engage staff with required analytical expertise and knowledge of R&D for the period of the inquiry.

The Commission is to issue an issues paper at the beginning of the inquiry process and to issue a draft report outlining recommendations for consultative purposes. A final report is to be provided to me as soon as possible, but not later than eleven months after receipt of these terms of reference.

Hon Steven Marshall MP

PREMIER OF SOUTH AUSTRALIA

3 / 2 / 2020

Transmittal letter

Wakefield House
Level 15, 30 Wakefield Street
Adelaide SA 5000

GPO Box 2343
Adelaide SA 5001

T: 08 8226 7828
E: sapc@sa.gov.au
W: www.sapc.sa.gov.au

DX56201
ABN 94 500 415 644

SAPC21D00001

The Hon Steven Marshall MP
Premier of South Australia
Level 15 State Administration Centre
200 Victoria Square
ADELAIDE SA 5000

Dear Premier

Inquiry into Research and Development in South Australia

In accordance with the terms of reference received by the Commission on 6 February 2020, we are pleased to submit the South Australian Productivity Commission's Final Report on the inquiry into Research and Development in South Australia.

This final report has been prepared after consultation with universities, research institutes, research finding bodies, state government departments, professional bodies and industry as well as careful deliberation of the submissions they made.

We acknowledge and thank them for their support, together with the Office of the South Australian Productivity Commission staff for their contributions in preparing this Final Report.

We note that in accordance with the *Premier and Cabinet Circular PC046* 'The Commission must ensure that the report is available on its website within ninety days of delivering the report…', unless you specify a shorter period.

Yours sincerely

Dr Matthew Butlin
Chair & Chief Executive

Mr Adrian Tembel
Commissioner

Prof Christopher Findlay AM
Commissioner

Prof Edwina Cornish AO
Commissioner

18 / 01 / 2021

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Key Messages

The Commission was asked to report on South Australian R&D: how it translates into economic performance and wellbeing; recommend actions that the South Australian Government state government might take to increase the output and productivity of South Australian-based public and private sector R&D; and, in doing so, increase the state's share of Australian Government funding for research and its rate of economic growth.

The Commission considers research and development is an essential element of South Australia being a vibrant, modern and competitive state. The benefits come from research and development that, across short to long-term timeframes:

- improves the quality of goods and services to South Australians, including services provided by government; and
- is an essential foundation for key sectors in the state's economy, leading to higher growth, employment and productivity.

For at least a decade the SA economy has had the second highest R&D intensity of the states (around 2 per cent of GSP) but its productivity performance has lagged Australia as a whole. This argues increasing the overall level of spending on R&D in SA is secondary to increasing R&D output and productivity from existing resources.

Business expenditure is below the national average, even though firms in the state have a higher propensity to spend on R&D, the issues being industry structure and firm size.

The expenditure by the higher education sector on R&D in SA grew substantially, from approximately $500 million in 2008, to approximately $830 million in 2018, largely funded by surpluses generated from teaching, which are highly dependent on international students. This is under pressure as a result of the pandemic.

There are signs the research performance of SA's higher education providers has weakened in recent years. Between 2006 and 2018, SA universities have experienced lower growth rates than the national average in all major sources of funding; the share relative of national funding dropped from 8.9 to 8.1 per cent; and, since 2014, average grants size for SA universities have been lower than the Australian average.

The Australian Government is a major source of R&D activity in South Australia, both through its national funding programs supporting university research and intramural research spending in SA, including DST and CSIRO. In 2018-19, around 16 per cent of Australian Government R&D expenditure occurred in South Australia, ranking the state second behind Victoria. That said, the relatively low level of collaboration with the Australian Government limits the potential benefits of this expenditure.

Spending managed by state and local government in SA relative to GSP is the highest of all the states. Little of the spending is funded by the state government (in 2019-20 this was $26 million of total expenditure of $130 million).

The Commission's review SA Government R&D activities over the past four decades showed examples of consistent long-term support in selected sectors – particularly agriculture. But the predominant picture was of churn in programs, redirections of effort, policies (health in particular) that reduced the capacity and productivity of R&D; and, apparently, little attention to performance, measurement and evaluation. A good deal of the R&D has not been linked to

downstream translation and innovation in the SA economy's key sectors, such as health, as found in the Commission's inquiry into health and medical research.

In short, R&D has not been harnessed well to play a strategic role in improving economic growth and wellbeing in South Australia over the past two decades. Addressing this is a pressing matter for the state's future.

The SA Government recently released the EXCITE strategic plan which includes initiatives to attract new research investment across the fields of STEMM to deliver innovative products and services. The Commission's analysis supports the core themes and key tasks in EXCITE relating to research and development. Implementation of the plan is in progress.

The Commission concluded that for R&D to be a strategic enabler of the state's performance, a consistent, long-term position on the strategic contribution of R&D and the policy actions to pursue it is essential. This includes ensuring those actions are directed both to strengthening upstream R&D in terms of excellence, output and productivity and strengthening its connection to downstream translation and commercialisation in sector value chains. They are key themes of both the Growth State and EXCITE strategies.

Those SA Government actions most importantly consist of the following policy instruments:

- government spending on its own research, programs to encourage R&D by business and support for research in universities;
- investing in and managing the government's research infrastructure assets, including opening access to its data for research and maximising the return from precincts;
- building the capability of the government's own research workforce and encouraging research bodies to act similarly, with focus on outstanding research leadership;
- building and leveraging relationships with research bodies in SA and beyond, especially the Australian Government (in relation to its R&D activities) and between business and research bodies; and
- the SA Government's procurement of goods and services.

The Commission's recommendations on specific policy actions build on EXCITE and are limited to additional matters including data access, research workforce and procurement.

The second conclusion is that means a stable, effective regime for executing the R&D strategy is essential, embedding accountability, budgets, timeframes, measures and evaluation in agencies and ensuring R&D is integrated into the relevant growth sector plans. Accordingly, other recommendations include the SA Government adopt clear goals and objectives for R&D, explicit budgets, independent measurement and evaluation and the capacity to allocate resources to the highest benefit to the state in terms of growth and productivity. To ensure a long-term, whole-of-government approach, the Commission recommends an explicit Ministerial accountability for R&D and an independent body to measure and comment on the performance and health of SA R&D. These changes would strengthen the relevant elements of the EXCITE strategic plan.

Finally, the Commission considers R&D is a long-term investment, requiring consistent support over time, based on progress against established milestones and careful evaluation to translate into commercial success. Stable, well-designed policies also need patience.

Executive Summary

The inquiry

The Commission's terms of reference require it to consider and report on R&D activity in South Australia; how it translates into economic performance and wellbeing in the state; and recommend actions that the South Australian Government might take in connection with South Australian based R&D to increase:

1. the output and productivity of South Australian-based publicly funded R&D;
2. South Australian based private sector R&D, and in so doing;
3. the state's:
    - share of Australian Government funding for research; and
    - rate of economic growth.

The inquiry was undertaken in the context of the South Australian Government's Growth State strategy and the government's EXCITE strategy, adopted in October 2020, to attract new research investment across the fields of STEMM to deliver innovative products and services.

The recommendations build on and complement these strategies, including by strengthening the SA government R&D architecture necessary to elevate R&D to a strategic role in lifting the state's economic growth and productivity.

Income growth, productivity and research and development

As in its health and medical research inquiry, the Commission starts from the position that research and development is an essential element of South Australia being a vibrant, modern and competitive state.

The benefits come from research and development that, across short to long-term timeframes:

- improve the quality of goods and services to South Australians, including services provided by government;
- provide essential foundations for key sectors in the state's economy, leading to higher growth, employment and productivity.

These benefits lead to more, higher paid jobs, higher living standards, employment and productivity.

The economic literature suggests research and development has a positive but indirect and long-term impact on economic growth and productivity. Research leads to innovation and translation, resulting in new and improved products, services and processes.

In addition to the contribution of research to productivity, the productivity with which research activity itself is undertaken is also important. More productive use of resources devoted to research develops a larger body of knowledge which is the basis of new ideas to produce goods and services. This applies to all research providers, not just the state government, but also business and universities.

Against that background, a key point is that the SA economy has for, at least a decade, had the second highest R&D intensity (2 per cent of GSP) of all the Australian states but its

productivity performance has significantly lagged Australia as a whole. SA total factor productivity has been flat for two decades and capital productivity has fallen over the past decade.

The Commission sums up its findings on state R&D policies and R&D effort as follows:

State policy and spending

- The Commission found (Chapter 2) the policy activity by the state is significant, including:
    - spending by SA agencies and funding by the SA Government;
    - shaping and managing a portfolio of research infrastructure assets; and
    - shaping and developing collaborative relationships within SA, including SA research institutions, and outside SA, including the Australian Government.
- There has been simultaneously significant churn in programs (short-lived, measures being adjusted, and spending being regularly redirected) and consistent ongoing support for research in agriculture and health and medical (SARDI and SAHMRI).
- The relative success of the state's initiatives cannot be assessed because evaluations of SA programs are rare and, other than for SARDI, the quality of evaluations is low and the follow up on recommendations is difficult to discern.
- Moreover, the contribution to R&D from the innovation precincts – the major infrastructure investment – is difficult to isolate from its other objectives. While on-site businesses anecdotally asserted the precinct was important to their development, the Commission could not find any credible, quantitative evaluation of the precincts' effectiveness to R&D. The Commission understands the innovation precincts have a broader focus than R&D activity. But it is important to understand their impact on R&D. This cannot be done on existing evidence.
- In October 2020, the SA Government released the EXCITE strategic plan which, among other things, includes several initiatives to attract new research investment across the fields of STEMM to deliver innovative products and services. The Commission's analysis and conclusions support the core themes and key tasks in EXCITE relating to research and development. That said, there are few details regarding how the plan will be implemented and embedded in the culture of agencies.

Analysing the funding sources of total State government R&D expenditure (around $130 million in 2019-20 – see Table 3.7) shows:

- after external sources of funds are removed, the balance funded by the state government is of the order of $26 million in 2019-20.
- excluding SARDI's base funding and the DIS's grant programs, the remaining $14 million was expended by individual agencies in relatively small amounts that vary substantially from year to year (see Table 3.6).
- programs administered by the Department of Innovation and Skills – around $4 million annually – are the bulk of the SA contestable funds.

There is some year-to-year volatility in the figures, as shown in Tables 3.6 and 3.7.

A key question is whether the funds the state contributes towards research are efficiently and effectively allocated. That is, would a reallocation of funding between areas increase the productivity of the overall research effort managed by the state? The Commission could find no process that addresses this matter. Moreover, the proportion of SA Government funding that is contestable is low. Contestability normally reveals the most productive uses of funds and increases the overall return.

Business expenditure

- The nominal amount of business expenditure on R&D is lower than other states and the intensity of that expenditure as a percentage of GSP is below the Australian average, even though firms in the state have a higher propensity to spend on R&D, the issues being industry structure and firm size.
- SA has a relatively high representation of SMEs, which tend to spend less on R&D compared to larger firms.

Higher education expenditure

- Higher education expenditure in SA has been increasing, although competitive grant success is declining and the state share of national spending by this sector has fallen.
- The most significant source of the growth in spending on research has been surpluses from student fees, which are now threatened (both nationally and in SA) by the response to the COVID 19 pandemic.
- The average grant size in Australian Research Council programs for South Australian universities has been lower than the Australian average since 2014. This reflects South Australia not winning new funding through the ARC Centres of Excellence. SA has submitted one application for a Centre of Excellence in that period.
- Compared with the national average, South Australian universities had a lower rate of applications per staff member for ARC funding. While application rates vary across years, generally South Australia had lower application rates for Discovery Schemes while applications for Linkage Schemes had higher application rates.
- The lower average grants, and application rate may suggest that SA universities lack sufficient scale or leadership to win funding in the larger ARC grant programs.
- In terms of the research workforce, the number of person years of effort (PYE) devoted to R&D in SA fell (from 2,067 to 1,848) over the period 2012-2018, compared to an increase in Australia (from 23,305 to 24,805) over the same period.

Australian Government expenditure

- The Australian Government both provides significant research funding to the university sector through national competitive grant and base funding and spends a disproportionate share of its total R&D spending in its agencies in South Australia.
- In 2018-19, approximately 16 per cent of Australian Government intramural expenditure on R&D occurred in South Australia, with only Victoria having a higher share of Australian Government expenditure.
- The Commission concluded this expenditure could generate higher benefits for the State and this opportunity could be exploited by the SA Government.

Collaboration

Effective collaboration is a key factor in obtaining more research funding and achieving better results. Universities Australia estimates that $10.6 billion in annual business revenue comes directly from partnering with universities, contributing $19.4 billion annually to Australia's income, and that business to researcher collaboration adds 30,000 full-time positions nationally[1].

- In SA, collaboration rates between the basic research sector and industry are in line with that of other states.
- Survey evidence suggests that Australian innovation-active businesses have low rates of collaboration on R&D. Over the past decade, around 5 per cent have collaborated on R&D.
- Data from the Office of the SA Chief Scientist indicate a significant performance gap both in Australia and in SA between the excellence of STEMM research outputs and the level of industry research collaboration. Overall, excluding Earth Sciences, 60 per cent of STEMM subfields in SA were placed as equivalent to performance in the bottom quartile (Q4) of the OECD for industry-research collaboration.[2]
- Agricultural research at the Waite campus in SA exemplifies the benefits of a high collaboration between the state, industry, other jurisdictions and the Australian government of a high performing field. SA has high rates of publication in the sector, attracts significant industry funds and has been recognized as one of the premier agricultural research precincts in the world. While there some stakeholders suggested that future performance may decline, the metrics considered by the Commission suggest it remains a strong performer by international standards.

The Commission's evidence

The Commission's evidence came from: 17 submissions; 62 consultations and 3 roundtables with stakeholders; information from government agencies; commissioned research; and the Commission's own research and analysis.

While the Commission reviewed a substantial amount of information, there were several important gaps. In particular, the Commission finds the lack of program evaluations of the R&D components of state strategy troubling. There are some exceptions like the 2016 review of SARDI.

The Commission's capacity to build the picture of the R&D sector in South Australia has been significantly limited by the range and quality of the available data. For sectors other than higher education, the ABS only publish total expenditure at the state group level as more detailed information comes from surveys with insufficient responses in South Australia for meaningful analysis.

Furthermore, while there have been previous analyses of South Australian Government expenditure on R&D, agencies have no requirement to regularly report their R&D expenditure. While agencies have assisted the Commission in identifying their expenditure, data was not

[1] Universities Australia (Cth), *Clever Collaborations: The Strong Business Case for Collaborating with Universities* (2017).
[2] OECD ranking of Australia for STEM fields of research and equivalent ranking of South Australia using measures of research performance and collaboration (2014-2018) using Incites Clarivate data.

available for all years for some agencies and it is likely that some R&D expenditure has been omitted.

Performance of research and development in SA

The Commission evaluated the performance of the overall R&D effort at three levels:

- overall productivity growth;
- macro indicators of research activity and outputs; and
- evaluations at the program level.

Overall productivity growth

As noted, while the SA economy has the second highest R&D intensity (2 per cent of GSP) of Australian states, SA's long term productivity performance has lagged Australia as a whole. For two decades, multifactor productivity has been flat and capital productivity has fallen significantly over the past decade (see Chapter 1). This compares adversely with the overall Australian economy where productivity has generally grown over the past decade.

At face value, the high level of R&D intensity in SA has had little impact on the state's poor productivity performance, suggesting several possible explanations including that R&D's output and productivity are low and that it is weakly linked to downstream translation, commercialisation and business.

Consequently, the Commission concludes that increasing the overall level of spending on R&D in SA is secondary to increasing R&D output and productivity from existing resources. It also concludes, the arrangements shaping the state government's support for research and development have not effectively supported the role of research, development and innovation as an enabler of employment, economic growth and productivity.

Macro indicators of research activity and outputs

The Commission examined indicators of the performance of the research and development system in the state, related to the level of activity and its outputs and processes. Table 7.1 sets out a selection of 'macro' indicators of the performance of the research system at the state level. They are drawn from Chapters 3, 4 and 6.

The indicators show positive trends in higher education spending and publications from that sector, including international collaborations, which are highlighted in Table EX.1. Indicators showing negative trends are the decline in the amount of and share of category 1 income and the reduction in academic staff devoted to R&D.

Some fields of research have strong elements of performance, including the quality of publications. According to the national research assessment (ERA), many research fields are performing at global level. In some areas, there is concern about their scale and fragility.

Other indicators considered were the role of the research workforce, in terms of its size and composition and the extent of collaboration among themselves and with industry (since collaboration is expected to raise productivity). One weak point is that the size of the research workforce has been falling.

The Commission was tasked to examine the performance of the research and development system in the state, related to the level of activity and its outputs and processes (see Chapter 4 for more detail).

Table EX1: Summary of R&D performance indicators

Indicator	Year	Current	10 years previous	Trend
Academic staff devoted to R&D (PYE)	2018	1,848	1,688	
University total research workforce [a] (PYE)	2018	5,300	4,523	
Australian Government expenditure ($m)	2018-19	340	308	
Business expenditure on R&D ($m)	2017-18	798	948	
No. patent applications	2019	444	605	
SA share of patent applications (%)	2019	5.2	6.2	
Higher education expenditure on R&D ($m)	2018	827	505	
SA Universities income from ARC ($m)	2018	38.2	33.1	
SA Universities category 1 income ($m)	2018	125	99	
SA Universities share of ARC income (%)	2018	6	6.5	
SA Universities share of category 1 income (%)	2018	7.5	8.6	
No. publications in the top 10% of citations	2019	1,047	515	
Publications with an industry co-author (%)	2019	1.9	2.4	
Publications with an international co-author (%)	2019	58.3	41.1	

a: Total research workforce includes academic staff, postgraduate students and other staff

Source: ABS 8109.0, ABS 8111.0, ABS 8104.0, Department of Education, Skills and Employment HERDC, Clarivate Incites Database, IP Australia

The Commission also examined the productivity of outputs from the academic sector (see Chapter 4). This measure suggests the performance in South Australia in more than one-third of fields was at or above those in other states, especially in mathematical and physical sciences, psychology and law. The balance of performance by field of research in SA is generally within the distribution. In other words, SA performs well in this measure.

With respect to application rates, since 2005 South Australian universities submitted 6.7 per cent of applications and received 6.1 per cent of funding approved by the ARC. This is despite having between seven and nine per cent of Australia's academic staff PYE devoted to research over this period. This may be the result of deliberate choices by institutions to contain the effort made in applications to those likely to succeed and win large grants, but it also has implications for the capacity of SA Universities to submit and win those grants. Research leadership is a critical issue.

The ABS, for the Commission, analysed the propensity of firms in South Australia to undertake R&D. It found that SA firms are generally more likely to spend on R&D compared to those in other states except in WA, after controlling for other influencing factors. The results also indicate that:

- large companies are significantly more likely to spend on R&D across Australia;
- as the company employment size increases the odds for the likelihood of the firm spending on R&D increases;
- the propensity for companies to spend on R&D increases as their total income increases; and
- younger firms are more likely to spend on R&D compared to older firms, controlling for other factors.

The implications for South Australia of larger businesses being more likely to spend on R&D are important given the relatively lower number of medium and large size businesses.

South Australian researchers and businesses are just as likely as businesses at the national level to collaborate on a patent application (see Table 4.4). South Australian organisations collaborated on 17.1 per cent of all standard patent applications between 2000 and 2019, in line with the national average of 17.3 per cent.

In comparing South Australia's R&D intensity to that of Australia in 2017-18, South Australia had approximately $17,800 less BERD per $1 million of Gross Value Added (GVA). The Commission estimates that of this difference, over $16,100 can be attributed to differences in industry structure, with a further $1,700 a result of lower R&D intensity within industry sectors.

South Australia had higher R&D intensity than for Australia in the sectors of agriculture, forestry and fishing; mining; electricity, gas water and waste services; rental, hiring and real estate services; and other services. South Australia's higher levels of R&D expenditure in agriculture, forestry and fishing are mainly as a result of the sector being larger in South Australia, despite these firms having a lower than average R&D intensity.

South Australian researchers and businesses are just as likely as businesses at the national level to collaborate on a patent application (see Table 4.4). South Australian organisations collaborated on 17.1 per cent of all standard patent applications between 2000 and 2019, in line with the national average of 17.3 per cent.

Evaluations at the SA Government program level

In Chapter 2, the Commission found there has been a considerable amount of activity by the state government, but also a lot of churn, with many programs being short-lived, measures being adjusted and spending being regularly redirected.

The Commission found relatively few evaluations of the R&D components of state strategy. The review of SARDI in 2016 was an exception. Overall, the Commission found few routine evaluations. Review, evaluation and performance measurement are not strengths in this area of public policy, which significantly restricts the capacity to take an evidence-based approach to government decision-making.

Two business related programs are of particular interest to the Commission. They are, firstly the elements of the Research, Commercialisation and Startup Fund which involve basic research to prove and develop concepts for new businesses. Second, the Commission is interested in the Go2Gov program which was recently established to encourage small firms to assist government agencies in responding to major challenges.

Similar schemes are observed in other countries, and by the Australian Government. Assessments of these schemes in SA are not available, but those applied to such schemes in the US are positive. In the Commission's view, these schemes are worthy of additional

attention including how they might be managed to complement those at national level. This is part of developing further the strategic relationship with the Australian Government.

The Commission also examined the contribution of investments in physical infrastructure to performance. The evidence of the contribution of the innovation precincts is difficult to determine. The Commission was unable to source any quantitative evaluation of the precincts' effectiveness in increasing R&D activity on the site or in the state. Businesses located on the sites anecdotally vouched for the importance of the precinct in their development. In the Commission's view, precincts can play a role in connecting business with research providers, and in facilitating virtual interaction as well as face to face interaction. In addition, there has been some feedback that for some state managed precincts, R&D was not a core focus of the development.

A key task at this point is to put in place the conditions, including governance, for driving effective cross-fertilisation and linkages between research and business. The design of new forms of governance of the precincts is identified in EXCITE, and in the Commission's view, is an urgent priority. A better networked set of precincts in terms of research interaction would add further value to their contribution, which is another matter which can be taken up in the design of governance arrangements. At same time, attention to alternatives will be important, and these include schemes which engage directly with business rather than via a spatial intermediary.

Conclusions

SA Governments have pursued a range of R&D policies and related programs over time and have made significant annual expenditure, both managed and funded by the state, linked to research activities. Some of this state-funded expenditure has evidently had significant positive consequences, especially in agriculture and to an extent in health. And the state has supported areas of acknowledged excellence and world class performance such as the Australian Institute of Machine Learning and the Waite Precinct/SARDI.

Overall, the Commission's view is that a more purposeful approach to research policy would lift the return to the state and make R&D a strategic contributor to the state's success. Such an approach would include attention to the activities that have direct impacts on research outputs, its ownership and management of its research infrastructure assets, using state spending to leverage additional activity by business, the universities and the Australian government and so on. The EXCITE strategy incorporates many of these elements.

That said, despite the continuing high flow of activity each year in other areas, the Commission is unable to conclude with clarity that state polices have been effective in encouraging research in the state. In part, this assessment is because of the presence of other drivers of research activity. But also, importantly, this assessment is more difficult because of the lack of information available at the program level with which to make an assessment, as evident in the earlier discussion of performance indicators and evaluation reports. This is one symptom that R&D currently plays a non-strategic role in the state's economy and historical policies.

There are other significant symptomatic weaknesses including:

- no visibility of the state government's whole-of-government spending on, and funding for, research and development;

- patchy information on the performance of, and returns from, the state's research and development activities: while there is solid evidence in some areas, there are complete gaps in others;
- no complete, transparent picture of the state's investment in research and development infrastructure and its performance especially in terms of the impact on R&D. In saying that, the Commission notes that some of this infrastructure has multiple purposes;
- no evidence to make systematic, evidence-based comparisons of the economic and social returns to South Australia from the alternative activities available to the government. The investment in research and innovation precincts by successive state governments is one example; and
- evidence, including from the Commission's health and medical research inquiry, of patchy, and overall insufficient, attention to the strength and depth of the state's research workforce.

In the Commission's view, addressing these weaknesses is a necessary condition for elevating R&D to a strategic contributor to the state's economic growth and productivity. Not to attend to these weaknesses significantly risks continuing the policy instability and churn evident over past decades.

Lifting research and development in South Australia

The terms of reference ask the Commission to recommend actions that the SA Government could take in connection with R&D so that policy translates to increased output and productivity in this state.

The simplest response would be to recommend that the SA Government spends more money on R&D. The Commission has chosen not to make a recommendation along those lines.

While it is likely, in the Commission's view, that increased overall spending may be beneficial in the future, addressing opportunities to improve R&D policy and making existing efforts by the SA Government more effective across several domains are the immediate priorities. The improved governance and information from addressing these priorities will enable the SA Government to make better decisions informed by evidence about R&D, including where additional resources can be justified and where existing resources can be redeployed.

The SA Government through its Growth State Strategy, the associated sectoral plans and the EXCITE strategy has established innovation and skills as a key enabling strategy to lift South Australia's economic growth and productivity. The Commission's conclusions align closely with the priorities of the EXCITE strategy as they relate to R&D, including its emphasis on research excellence, collaboration and an enabled future research workforce. The Commission agrees with importance of the sectoral value chains linking research, development, innovation and translation as the basic mechanism by which upstream research contributes to employment, economic growth and productivity. The priority given in EXCITE to ensuring that the growth plans for priority industry sectors in South Australia are underpinned by a high performing research and innovation value chain is appropriate.

The Commission also notes EXCITE is at an early stage of implementation, with much work identified and remaining to be done.

The Commission's approach is to recommend some additional policy actions that complement EXCITE and to recommend actions to strengthen the South Australian Government's policy architecture to:

- focus on lifting the performance of the state's research and development effort; and
- integrate research, development and innovation into areas of focus for economic growth.

In devising these recommendations, the Commission has applied five principles.

- State-wide view: take a state-wide, cross-sectoral and technology neutral perspective to the state's overall R&D strategy.
- Relevance: be prepared to set priorities relevant to the state but reserve resources for unexpected opportunities, make contestable either the mechanism for delivery when directions are set or choice of topics otherwise, but in neither case compromise on excellence.
- Time horizons: use strategies with a series of time horizons organised with critical milestones that drive decisions about whether to continue investment in other areas, plus a framework for risk management.
- Simplicity, transparency and accountability in policy: establish clarity of purpose, specify performance metrics, do full costing, evaluate programs and reduce duplication.
- Collaboration: remove impediments to adding value to locally provided resources through collaboration with businesses or collaborators locally and elsewhere. Collaboration facilitates access to research elsewhere that might be relevant locally.

The Commission recognises that basic research is part of a chain of value adding activities that ultimately contribute to innovation, productivity and growth, and that whatever architecture is put in place to bolster the performance of the upstream part of that chain should be easily adapted to further institutional developments downstream.

The Commission also concluded that a statement specifically for research and development that explicitly complements EXCITE, given its early stage of implementation, would be useful in ensuring a transparent and accountable focus on the research and development 'engine room'. Such a statement would strengthen accountability for state's research and development activities, strengthen the capacity to deliver the EXCITE strategy and elaborate further on the relevant EXCITE themes. The proposals here also elaborate further with respect to the consideration of whole of government approach, the specification of objectives, the collection of measures of performance and systems of evaluation.

The Commission's recommended approach

The Commission summarises its recommended approach to lifting research and development in South Australia as follows:

- Establish, with clarity and visibility, the intended strategic role for R&D in South Australia's future with some specific goals in priority areas. The Commission sees this as a further elaboration of elements of relevant parts of the EXCITE strategy.
- Integrate this enabling role into all relevant parts of the state's economic development strategy, covering the state's direct activities as well as its indirect activities such as its

relationships with the research institutions operating within South Australia, including those of the Australian Government.

- Strengthen the research and development system architecture to better pursue the state's research and development goals by:
    - Systematically identifying, measuring and tracking the resources the state commits to research and development and the return from those resources, including its research infrastructure assets
    - Establishing a state-level budget for research and development activities by the state with clear performance goals, performance measures and accountability devolved to agencies
    - Over time, lift the contestability for the state's funding of research and development based on evidence and performance
    - Review the justification for additional budget over time.
- Declutter the regulatory framework governing research – further detail is in the Commission's recommendations in its health and medical research inquiry – including greater access to state-held and generated data.
- Build systematically and purposefully, a step change in the capability of the parts of the state's research workforce that the SA Government directly employs or indirectly influences and encourage research institutions to do likewise.
- Use its procurement to selectively provide opportunities for innovative solutions, including those built on SA research and development.

The Commission makes three linked recommendations to address the first three elements of its recommended approach.

The Commission concluded that, given the churn and instability of SA's public policy for R&D over recent decades, an effective accountability framework to support the delivery of the intended strategic role for in SA is essential. This framework needs to have clear goals, clarity of objectives, budgets, ongoing review and the capacity to allocate resources to the highest benefit to the state in terms of growth and productivity.

Importantly, the accountability framework would include a transparent set of indicators that describe trends and performance of the state's R&D, including the government's own activities and the resources committed to them. The Commission considers the measurement framework needs to be designed by independent experts, with the indicators being published regularly with independent expert commentary. These are very important tasks to ensure consistent, sustained focus on progress. The macro measures in Table EX.1 is an indicative, rough starting point, the EXCITE strategy identifies a range of indicators and the Commission received advice from several participants about current practice in universities and elsewhere. The indicators would also include information on SA Government expenditure and funding such as set out in Table 3.6.

Regular assessment and reporting are integral to ensuring government has a clear understanding of performance and alternatives. Noting that much research and development is long term, reporting timeframes need to be appropriately set.

Strengthening the state's R&D architecture

The Commission concluded that the totality of SA public policy for R&D points to a critical missing link in SA's R&D policy framework being consistent, strategic leadership — ensuring that the different elements of policy work together to optimise impact. This leadership integrates both 'top down' whole-of-government perspective with 'bottom up' agency and sector perspectives.

The Commission concluded the architecture for R&D is weak in terms of its capacity to set and prosecute a whole-of-government R&D policy. In practice the architecture appears to support a largely bottom up approach, with priorities and decision-making being vested in agencies where the majority of R&D funding, capability and infrastructure reside. Important decisions on how the scarce resources of government are allocated are driven within individual agencies, making it difficult for policy makers to operate in a truly strategic manner. The Commission concluded that elevating and consolidating strategic decision making within the architecture of government is a necessary step to sharpening the efficacy of SA R&D policy.

The Commission considered several possible options and was assisted by the feedback and advice from inquiry participants. One option could be to assign strategic responsibility for R&D policy within a single ministry. Another option could be to create a new mechanism that requires R&D policy across portfolios to be monitored and regularly reviewed. A key consideration was to identify an approach that did not add a further layer of bureaucracy and decision making and did not diminish the accountability of line Chief Executives for delivering their objectives including sector growth plans.

The Commission opted for an approach that effectively integrates the contribution of research and development into sectoral plans; establishes a whole-of-state strategic perspective on the contribution and performance research and development; and considers strategic options for the state.

It concluded that a strong Ministerial level focus on the state's whole of government R&D activities would strengthen attention to the health and effectiveness of the state's R&D foundations and emerging future opportunities. Executive accountability for delivering sectoral growth plans, including ensuring their R&D foundations were fit for purpose, would rest with agency chief executives to avoid any suggestion of creating an additional layer of decision-making or bureaucracy.

A Chief Advisor with a strategic scope for all research, development and innovation would support the Minister, with strong authorities including to; advise on R&D strategy and the effectiveness of R&D in industry sector plans; have access to and commission rigorous evaluation; and sponsor a community of practice among R&D professionals. It would also encompass areas of research beyond STEMM that can improve the performance of the SA economy, including government services.

In practical terms, this expands and strengthens the role of the SA Chief Scientist. It would be a strong advisor role that would work highly collaboratively with agency chief executives and their agencies who, in turn, would be accountable for working collaboratively with the Chief Advisor.

The Commission proposes that this Minister would be assisted by an external independent, expert advisory body with broadly based skills and a strategic perspective, with the majority of members coming from outside South Australia. The activities of this body would include: the design of the set of performance indicators and information; compilations and publication of

the information; expert, independent commentary on the performance of SA R&D; and advice to the Minister on issues requiring attention, such as areas of weakness, including recommendations for investigative work. The Commission envisages the Minister would, as appropriate, ask the Chief Advisor and/or relevant chief executive to respond. This independent body could also validate the evaluation design of proposed evaluations of SA Government programs and receive a copy of the evaluation reports when completed. To manage the inherent conflict between the roles of this body (review and assessment) and the Chief Advisor (strategy and implementation), the Commission considers the Chief Advisor ought not be a member of the independent body although clearly both will work closely.

The Commission considers strong independence for the expert advisory body, underpinned by statute, is essential to maintaining a long-term, strategic and objective focus on the health and performance of the state's R&D effort.

The proposed architecture strengthens, extends and clarifies the state's current architecture. Over time this structure can evolve to include complementary institutions with a greater focus on translation, but which would be lie within the remit of the Minister. Their design however is beyond the scope of this inquiry.

Other recommendations

The Commission also recommends that the South Australian Government:

- builds strategic partnerships with major Australian Government research agencies located in South Australia to leverage their significant intramural research in SA, build nationally/globally significant research scale and impact in areas attracting long term Australian Government intramural support; and maximise alignment between research and innovation priorities and the state's economic development goals;
- maximises the net benefits from existing research and innovation precincts by: ensuring each Innovation Precinct/Neighbourhood has a strong governance structure with performance metrics; promoting research and development and collaboration among participants; ensuring clear objectives, ongoing performance measures and regular reviews are established; measuring the net benefits; and reviewing actions to promote relationships between business and research providers;
- provides support associated with government procurement to encourage the development of innovative goods and services;
- assists in maintaining and growing the capability of the state's research workforce by having the Chief Advisor: advise the Minister on the adequacy of the workforce, especially research leadership; advise relevant Chief Executives about the research workforce in their agencies; and engage with universities to encourage them to report on their strategies for management on the matters of research leadership and professional development of their research workforces;
- enables South Australian researchers to benefit from access to South Australian public sector data and from inter-jurisdictional data linkage opportunities whilst ensuring robust privacy protections are guaranteed by developing and enacting appropriate information privacy legislation; and
- in cooperation with universities and industry, develops, maintains and promotes a register of key research and development infrastructure available for use in South Australia (including national infrastructure networks).

Summary of Recommendations

Recommendation 5.1: Central information register of R&D infrastructure

The Commission recommends that the state government, in cooperation with universities and industry, develops, maintains and promotes a register of key research and development infrastructure (including national infrastructure networks) available for use in South Australia.

Recommendation 5.2: Access to South Australian Government data

To enable South Australian researchers to benefit from access to South Australian public sector data and from inter-jurisdictional data linkage opportunities whilst ensuring robust privacy protections are guaranteed in statute, the Commission recommends that the South Australian Government develop and enact information privacy legislation that:

- complements the *Public Sector (Data Sharing) Act 2016*;
- streamlines and clarifies the current regulatory environment as it relates to the collection, storage, use and disclosure of public sector data in order to enhance access to it; and
- ensures that robust privacy protections are in place.

Recommendation 7.1: Overall framework

To add to the contribution of research and development to growth in South Australia, the Commission recommends that the South Australian Government:

- establishes long term state-wide goals for lifting the volume, productivity and economic impacts of R&D, sets quantitative targets, such as the state share of national grant funding, collaboration with business and rates of commercialisation, to guide progress towards those targets;
- designs, strengthens and implements accountability, budgets, measurement and evaluation to support the delivery of this vision, including through the state's sectoral growth plans. In this respect the activities available to the state government include expenditure directly related to research, procurement (and its elements that have a research component), management of assets relevant to research and management of relationships with others in the state who contribute to research activity, including the Australian government, business and universities;
- strengthens the government's architecture for R&D to pursue these goals and the accountability for their delivery;
- makes a state government strategic plan for research and development addressing all the tools available to it, including: expenditure directly related to research; government procurement and its elements that have a research component; management of assets relevant to research; management of strategic relationships with others in the state who contribute to research activity, including the Australian government; business and universities; and building the capability of the government's own research workforce and encouraging research bodies to act similarly; and

- incorporates in these actions the scope to develop existing partnerships, the role of precincts, policy on use of public data, the scope to apply procurement policies and attention to research leadership.

Recommendation 7.2: Accountability

To make operational the vision in which research, development and innovation is accepted as a contributor to long run growth, and building on EXCITE and other relevant policies, the Commission recommends that the South Australian Government establishes a clear, transparent accountability framework in which:

- clear state-wide goals for research and development in the short run and in the long run are adopted;
- the intended purpose and the nature of the benefits in the short and the long term of each of the state's actions in all agencies to support and increase research and development is clear;
- the actual contribution from, and performance of, the state's actions in all agencies to drive that contribution is measured and evaluated systematically and reported transparently;
- principles that support the efficiency of actions related to research and development are shown to have been applied such as:
    - contestability in deciding the composition of the state's portfolio of support for research and development, including its infrastructure assets; and
    - systems of gateways and milestones for the assessment of project progress;
- an independently designed set of transparent performance indicators for understanding the overall performance and trends in the state's R&D performance is established, with ongoing compilation, regular publication and commentary on performance in work led by external independent advisors. These measures include whole-of-government resources committed to research and development, including recurrent expenditure and research and development assets, and the performance of those activities.

Recommendation 7.3: Strategic architecture for research and development activity

To implement the accountability regime, the Commission recommends that the South Australian Government establish a strategic architecture for this purpose which, considering the principle of avoiding the introduction of an extra layer of management to existing arrangements, links:

- a Ministerial level responsibility for Research and Development as a key part of the overall Innovation and Skills portfolio linked to the state's innovation and skills strategy;
- a Chief Advisor for Research, Development and Innovation;
- an expert Independent Advisory Body for Research, Development and Innovation; and
- chief executives of relevant agencies.

The Minister is accountable for improving the contribution to South Australia from its research and development activities, including by:

- developing and proposing a whole-of-government Strategic Plan for research and development in recommendation 7.1 for consideration and approval by the South Australian Government;
- oversight of progress against the plan, including the performance of agencies in improving their activities and executing the state's growth strategy and the outcomes achieved; and
- publicly reporting progress against the plan.

The Chief Advisor advises the Minister and the Government on research and development matters and related matters including:

- engage with government agencies, the Australian Government, business, research institutions and other relevant stakeholders on matters pertinent to the strategy or related matters;
- lead the development of the whole-of-government Strategic Plan for research and development in recommendation 7.1;
- advise on the South Australian government's support for research and development including its integration into the state's growth strategy and relevant growth sector plans;
- encourage rigorous evaluation of research, development and innovation activities of the South Australian Government and have access to all such information; and
- sponsor a community of practice of the senior agency officials who are accountable for research and development in their agencies.

The Independent Advisory Body provides the Minister with expert, independent advice on the state's strategy and strategic opportunities, and provides oversight and commentary on South Australia's research, development and innovation performance in recommendation 7.2. It also leads the design of the performance measurement framework includes transparent reporting on targets, budgets, performance measures, evaluations and resources among other matters. Half of the membership would come from outside the state. The body would be given strong independence through statute.

Agency chief executives are accountable for effectively integrating the government's research and development activities into the relevant growth sector plans and other relevant activities for which their agencies are accountable.

Recommendation 7.4 Strategic relationships, infrastructure and collaboration

As part of the state's approach for increasing the amount, quality and contribution from research and development in South Australia, the Commission recommends the South Australian Government builds enduring strategic partnerships with major Australian Government research agencies to:

- leverage the significant Australian Government investment in intramural research in South Australia, especially DST and CSIRO. With respect to CSIRO, further develop the work program with and reporting process with senior staff responsible for CSIRO's

SA operations. With respect to DST, noting the relationships of universities with DST and DST's approach to partnerships (including through the DISP arrangements), support their extension to other research providers and the private sector in SA.

- build nationally/globally significant research scale and impact in areas that attract long term Australian Government intramural support;
- maximise alignment between national research and innovation priorities and the state's economic development goals, including in the alignment of state and Australian Government programs (following a review state policies and programs to identify opportunities for state programs to complement those of the Australian Government that are available to SA business); and
- develop and execute a plan to increase Australian Government investment research infrastructure located in South Australia as part of the EXCITE strategy and the state's strategic plan for research and development proposed in Recommendation 7.1.

Recommendation 7.5: Maximise the net benefit to the state from research and innovation precincts

To maximise the net benefit to the state from its significant investment in science and innovation precincts, and noting governance structures recently established for them, The Commission recommends that the South Australian Government:

- following the proposal in EXCITE, ensures that each Innovation District/Neighbourhood has a strong governance structure together with a suite of 'metrics of success'.
- emphasizes the promotion of research and development and collaboration among participants in the precinct including universities, businesses and state agencies, including through the application of new governance structures;
- ensures research, development and innovation precincts have clear objectives, ongoing performance measures and regular reviews as part of managing the state's research assets to optimise their value to the state;
- measures the benefits and costs of its investment, particularly in relation to its impact on additional research and development; and
- reviews existing measures which are designed to promote relationships between business and research providers which take account of their complementarity with precinct operations.

Recommendation 7.6: Support associated with government procurement

To encourage research activity associated with the South Australian Government's procurement activities the Commission recommends that the South Australian Government require each relevant agency to:

- facilitate research which is associated with government procurement, including by:
    - developing information on local research and development capability in universities, other research institutions and businesses;
    - making public forward procurement needs that require significant different or innovative solutions compared with the past; and

    - establishing forums in which both items can be discussed.

- set tender terms that ameliorate biases against local research groups, for example, by allowing new groups to compete based on expertise rather than years of experience; and
- in program evaluations in these areas, benchmark local programs against comparable international programs, and check for opportunities to align with and add value in the local operation of Australian Government programs.

Recommendation 7.7: Research leadership and workforce

To maintain and grow the capability of the state's research workforce to underpin the proposed State's strategy for research, development and innovation, the Chief Adviser:

- advise the Minister on the adequacy of the state's research workforce, including the quality and depth of the research leadership in the areas bearing on the state's research, development and innovation strategy;
- engage with, and advise, relevant Chief Executives about the research workforce in their agencies, with particular attention to the research leadership and its relevance to the strategic plan; and
- engage with universities and research institutions to encourage them to report on their strategies for management on the matters of research leadership and the professional development of their research workforces. This may provide the basis for support from the SA Government to recruit key talent.

Acronyms

ABMC	Adelaide BioMed City
ABS	Australian Bureau of Statistics
ABSBR	Australian Bureau of Statistics Business Register
ACGR	Australian Competitive Grants Register
ACIAR	Australian Centre for International Agricultural Research
AGD	Attorney General's Department
AGRF	Australian Genome Research Facility
AIML	Australian Institute for Machine Learning
ANDS	Australian National Data Service
ANSTO	Australian Nuclear Science & Technology Organisation
APRIL	Australasian Pork Research Institute Limited
ARC	Australian Research Council
ARDC	Australian Research Data Commons
ARENA	Australian Renewable Energy Agency
ASDAF	Australian Space Data Analytics Facility
ATO	Australian Taxation Office
AWRI	Australian Wine Research Institute
AWQC	Australian Water Quality Centre
BERD	Business Expenditure on Research and Development
BioSA	Bio Innovation South Australia
BIT	Business Income Taxation
BLADE	Business Longitudinal Analysis Data Environment
CAGR	Compound Annual Growth Rate
CAHLN	Central Adelaide Health Local Network
CNCI	Category Normalised Citation Impact
COVID-19	Corona virus disease of 2019
CRC	Cooperative Research Centres
CSIRO	Commonwealth Scientific and Industrial Research Organisation
CSO	Community Service Obligation
DEM	Department for Energy and Mining

DEW	Department for Environment and Water
DHW	Department for Health and Wellbeing
DIS	Department for Innovation and Skills
DST	Defence Science & Technology
EDB	Economic Development Board
EI	Engagement and Impact
ERA	Excellence in Research for Australia
FTE	full-time equivalent
GDP	Gross Domestic Product
GSP	Gross State Product
GSSA	Geological Survey of South Australia
GUF	general university funds
GVA	Gross Value Added
HDR	higher degree by research
HERD	Higher education expenditure on Research and Development
HERDC	Higher Education Research Data Collection
HMR	health and medical research
IP	intellectual property
IPPs	Information Privacy Principles
IT	information technology
MDPP	Medical Devices Partnering Program
MFP	multifactor productivity
MISP	Meat Industry Strategic Plans
MMI	Modern Manufacturing Initiative
MMS	Modern Manufacturing Strategy
MRFF	Medical Research Future Fund
NCRIS	National Collaborative Research Infrastructure Strategy
NeCTAR	National eResearch Collaboration Tools and Resources
NHMRC	National Health and Medical Research Council
NISA	National Innovation and Science Agenda
OECD	Organisation for Economic Co-operation and Development
PhD	Doctor of Philosophy

PIRSA	Department of Primary Industries and Regions
PRIF	Premier's Research and Industry Fund program
PSF	Physical Sciences Fund (NSW)
PYE	person years of effort
RCSF	Research, Commercialisation and Startup Fund
R&D	research and development
RDC	Research and Development Corporations
RDS	Research Data Services
RSP	Research Support Program
RSSA	Rural Solutions SA
RTP	Research Training Program
SAHMRI	South Australian Health and Medical Research Institute
SAPC	South Australian Productivity Commission
SARDI	South Australian Research and Development Institute
SAVCF	South Australia Venture Capital Fund
SBIR	Small Business Innovation Research Program
SISP	Sheep Industry Strategic Plans
SME	small and medium enterprises
SNA	System of National Accounts
SRA	Strategic Relationship Agreement
SRI	Science Research and Innovation
STEM	science, technology, engineering and mathematics
STEMM	science, technology, engineering, mathematics and medicine
STI	science, technology and innovation
STTR	Small Business Technology Transfer Program
TAFE SA	Technical and Further Education South Australia
TechinSA	(formerly Bio Innovation SA)
UniSA	University of South Australia
UoE	Unit of Evaluation
WRI	Waite Research Institute

1. Introduction

1.1 The inquiry

The terms of reference task the South Australian Productivity Commission (the Commission) to investigate research and development in South Australia and to make recommendations on actions, including advice to the Australian Government, the state government can take on:

- the role and settings of policy levers available to the state government; and
- the effectiveness of various government interventions aiming at increasing R&D efficiency and outputs.

The concern is that, over the last two decades, South Australia's share of activity in R&D has been shrinking:

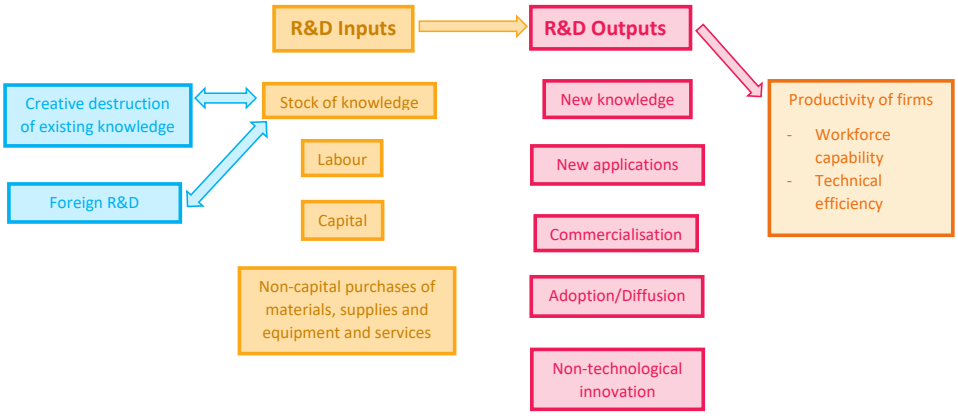
- Business expenditure on R&D (BERD) has been relatively static in South Australia over the ten years to 2015-16 with SA's share of national BERD falling from a high of 5.8 per cent in 2011-12 to 4.6 per cent in 2015-16.
- Higher education expenditure on R&D (HERD) grew more slowly in South Australia than the national average between 2006 and 2016, with SA's share of Australian HERD falling from 7.3 to 6.5 per cent.
- Intellectual Property Australia data indicates that the number of patent applications filed in South Australia has fallen 12 per cent between 2011 and 2017.

1.2 Research and Development and Productivity

Activity carried out to generate new knowledge is regarded as R&D, irrespective of its purpose, which could be economic benefit, addressing societal challenges or simply having the knowledge itself[3]. A simplified representation of the system of relationships around R&D activity, innovation and 'spillovers' of knowledge is shown in Figure 1.1. It illustrates that a critical input to R&D output is knowledge previously generated by the domestic economy and knowledge generated internationally. R&D activity can be viewed as a flow where inputs including finance, people and infrastructure are transformed into outputs (e.g. journal articles or patents), subsequently leading to outcomes such as new knowledge, new or improved products and new or improved processes, all of which contribute to economic growth.

[3] OECD, Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities (OECD Publishing, Paris, 2015).

Figure 1.1: Stylised R&D framework



Source: Constructed by SAPC based on a framework developed by the Australian Productivity Commission: Sid Shanks and Simon Zheng, Econometric Modelling of R&D and Australia's Productivity, Staff Working Paper (2006)

1.3 The economic importance of research and development

A fundamental driver of living standards is the productivity with which natural resources, labour and capital are used in the production of goods and services. While several factors drive productivity performance, the literature reviewed by the Commission indicates that research likely plays a role. While that link is not easy to identify, research is connected to application and thereby to productivity growth in complex innovation systems, which leads to new and improved products, services and processes.

Income growth contributes to both welfare and equity ambitions and raises the average level of wellbeing in the community through higher living standards. It also generates a greater capacity for governments, including at state level, to be responsive to community expectations and to meet new challenges. It follows that governments devote resources to encouraging R&D and innovation. Indeed, the Commission considers SA should pursue R&D and innovation as a core enabling strategy to lift economic performance.

The Australian Productivity Commission's report into Public Support for Science and Innovation 2007 identified two strong rationales for public funding support of science and innovation. The first is that publicly funded R&D contributes to innovation in government programs and services, even if this research is not carried out within the public sector.

The second rationale is the existence of spillovers. Spillovers represent the transfer or involuntary leakage of technological information which provides a flow of benefits to the economy (businesses and households). However, the Australian Productivity Commission found that spillovers themselves are insufficient to justify public support for R&D.

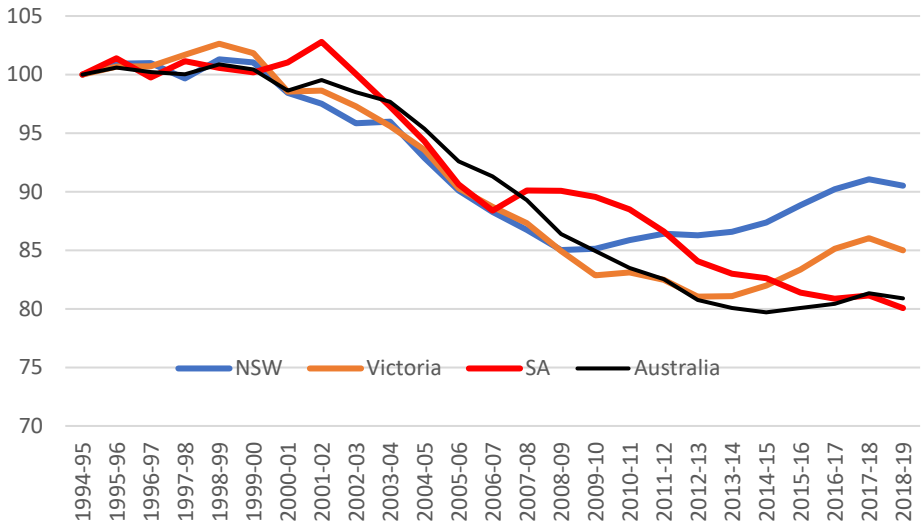
Public support for R&D needs to result in private expenditure that would not otherwise have been made; this is referred to as 'additionality'. Government interventions need to ensure that use of public funds stimulates new R&D rather than displacing private spending.

The private returns to R&D are generally found to be positive, and higher than those for physical capital. (Australian Department of Industry Innovation and Skills, Office of the Chief Economist, *Australian Innovation System Report* 2016). These relationships may in part be explained by the contribution of R&D to innovation which in turn is estimated to account for around half of long-term GDP growth in the OECD (OECD Innovation Strategy 2015: *An Agenda for Policy Action*). The literature also suggests that R&D activities can explain up to 75 per cent of total factor productivity growth, once externalities are considered.

In this context, it is useful to consider the state's productivity performance. The Commission recently published an analysis of South Australia's productivity over the past 25 years[4]. Between 1994-95 and 2003-04, labour productivity and multifactor productivity (MFP) were reasonably strong for both Australia and South Australia with capital productivity declining slightly. After 2003-04, labour productivity continued to grow for both Australia and South Australia, albeit at a slower rate, while there was a steep decline in capital productivity.

As illustrated in Figure 1.2, South Australia experienced a 20 per cent fall in capital productivity from 2001-02 to 2013-14, in line with the national trend. Since then, national capital productivity has stabilised while SA's capital productivity has continued to fall.

Figure 1.2: Index of capital productivity performance in Australia and selected states, 1994-95 to 2018-19.



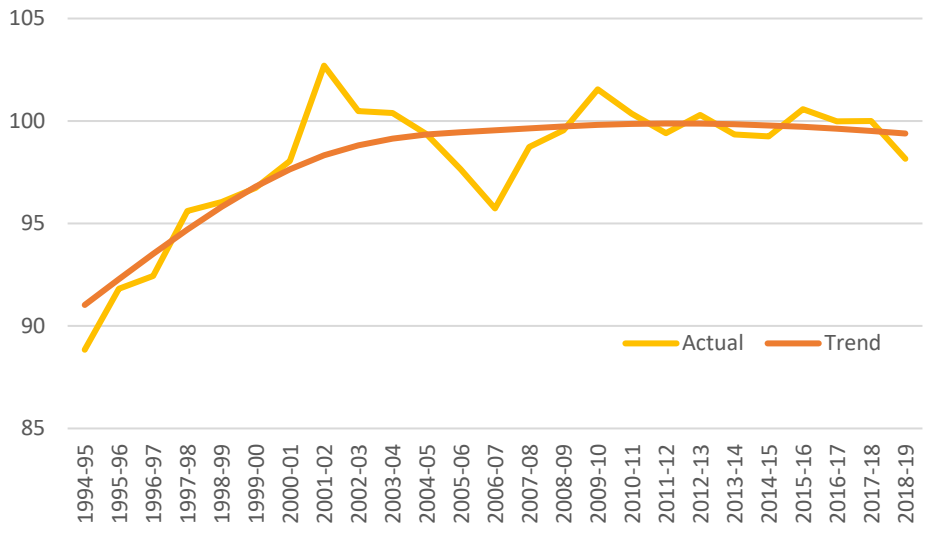
Source: Data derived from ABS Catalogue No. 5260.0.055.002 Estimates of Industry Multifactor Productivity, 2018-19 and provided to the Commission in Dean Parham, A Data-driven Investigation of South Australia's Productivity Performance, SAPC Research Discussion Paper No.1 (September 2020)

The main contributor to weaker productivity growth at a national level has been weaker output growth. Output grew at only 1.3 per cent a year between 2003 04 and 2017-18.

In South Australia, MFP has reached a standstill. In the period before 2003-04, labour productivity and MFP were reasonably strong and capital productivity was reasonably flat. After 2003-04, labour productivity continued to grow, albeit at a slower rate, while there was a steep decline in capital productivity. These two developments had an offsetting effect on MFP, which stagnated. The performance of South Australian MFP is shown in Figure 1.3.

[4] SAPC Research Discussion Paper No. 1.

Figure 1.3: South Australian multifactor productivity (Index 2017-18=100)



Source: Data derived from ABS Catalogue No. 5260.0.055.002 Estimates of Industry Multifactor Productivity, 2018-19 and provided to the Commission in Dean Parham, A Data-driven Investigation of South Australia's Productivity Performance, SAPC Research Discussion Paper No.1 (September 2020)

The Commission's research suggests that stronger R&D performance often leads to improved economic performance and growth. In addition, higher productivity, in R&D effort, is also expected to provide stronger economic growth and productivity.

1.4 R&D policy instruments

Various policy instruments are available to government to influence the amount of R&D undertaken across the economy or in particular markets. Such policies need to consider the provision of direct or indirect support, supply and demand for R&D and whether to target entities and sectors or apply it more generally in the economy. R&D policy instruments may also have a local or regional focus or seek to have a broader influence on innovation systems.

As policy makers', practitioners' and academics' understanding of research, development and innovation and its role in social and economic development have progressed, so have the number and characteristics of policy settings. Policy makers have advanced a number of different typologies of innovation policy instruments.

Table 1.1 summarises the impact of various instruments that focus on the supply of or the demand for innovation. It also takes into account a range of innovation policy goals and shows how the various innovation policy instruments relate to these goals. Many of these policy options relate to more than one goal.

Table 1.1: Policy instruments

Instruments	Orientation		Goals						
	Supply	Demand	Increase R&D	Skills	Access expertise	Improve systemic capability	Enhance demand	Improve framework	Improve discourse
Fiscal Incentives for R&D	●●●		●●●	●					
Direct Support to Firm R&D	●●●		●●●						
Training and Skills	●●●			●●●					
Entrepreneurship Policy	●●●				●●●				
Technical Services & Advice	●●●				●●●				
Cluster Policy	●●●					●●●			
Support Collaboration	●●●			●	●	●●●			
R&D Innovation Network Policies	●●●					●●●			
Private Demand for R&D		●●●					●●●		
Public Procurement		●●●	●●●	●●			●●●		
Pre-Commercial Procurement	●	●●●	●●●	●●			●●●		
R&D Inducement Prizes	●●	●●	●●				●●		
Standards	●●	●●					●	●●●	
Regulation	●●	●●					●	●●●	
Technology Foresight									●●●

●●● = major relevance, ●● = moderate relevance, and ● = minor relevance to the overall orientation and stated innovation policy goals of the listed innovation policy instrument

Based on: Edler and Fagerberg, Innovation policy: What, why, and how; Oxford Review of Economic Policy (February 2017)

1.5 Commission's approach

The Commission is required to take a broad perspective in developing advice for the South Australian Government. It must consider the broad interests and experience of state government agencies, universities, research institutions, industry, relevant peak bodies and other stakeholders.

Consultation and engagement with stakeholders are essential aspects of our work and, together with robust research and evidence-based analysis, are the foundation for quality advice and recommendations to government. Transparency, including publication of the submissions received by the Commission, is also an important part of this process.

The Commission acknowledges with thanks the assistance from state government departments, universities, research institutions, industry, relevant peak bodies and other stakeholders. In particular, the Commission extends its thanks to the Chief Scientist of South Australia for providing a significant amount of research data and access to numerous background papers.

1.6 Structure of the report

The report is structured as follows:

- Chapter 2 presents an overview of the policy and regulatory environment for R&D in South Australia and its evolution over the past four decades;
- Chapter 3 sets out R&D funding and the level and patterns of expenditure;
- Chapter 4 discusses the measurement of R&D performance in South Australia, including the effect on productivity;
- Chapter 5 considers the capital factors affecting R&D performance, including research infrastructure, funding, and access to data;
- Chapter 6 considers the human capital factors affecting R&D performance, including local demographics, the research workforce and collaborative models; and
- Chapter 7 sets out the Commission's conclusions and recommendations.

2. Policy environment

This chapter provides an overview of past and present state government policies and programs in R&D. The contributions of Australian government policy, programs and expenditure and of the higher education sector are also outlined. In addition, selected programs in other Australian jurisdictions are noted.

2.1 South Australian Government R&D policy

There are two components to R&D policy within the state. The first is the upstream component (basic research) which is largely contained within the university and research institute sectors. The second component is the downstream application which is focussed on commercialisation (business). While local success is heavily influenced by local upstream research, the Commission recognises that some research can be imported; however, local capacity in both upstream and downstream components assists in the translation of imported research.

2.1.1 History of R&D as an economic development policy

A comprehensive summary of the SA policy framework through the early years of the 21st century — including the Economic Development Board (EDB) reports, South Australia's Strategic Plan, iterations of the Premier's Science Council, and strategies including the '10 Year Vision for Science Technology and Innovation' and 'Investing in Science' — appears in the Draft Report of this inquiry.

Figure 2.1 presents a timeline of selected R&D-related policy changes introduced by Australian and SA governments since 1982. Successive governments in South Australia have pursued R&D policies through myriad initiatives, with public support well established in areas of agriculture, food and agribusiness, manufacturing, minerals, bioscience, water and environment, defence, and health and medical research (HMR is covered in a separate inquiry). More recently, the policy focus has expanded to engineering and technology-related industries. The state also has long-standing investments in R&D institutions and science and technology precincts. Since 2015-16 more than half of new funding for R&D measures ($125.3 million) was committed to research institutes and science and technology precincts, including $48.7 million to build Lot Fourteen and $44 million to build SAHMRI 2.

Figure 2.1: Timeline of key R&D policy changes – 1980 to 2020

Australian Government		South Australian Government
1989: *Primary Industries and Energy Research and Development Act 1989* established the modern model for rural RDCs.	**1980s**	1982: Technology Park Adelaide established at Mawson Lakes.
1991: Grape and Wine Research and Development Corporation established and headquartered in Adelaide, which later became Wine Australia.	**1990s**	1992: The South Australian Research and Development Institute (SARDI) established.
2004: National Collaborative Research Infrastructure Strategy (NCRIS) updated.	**2000s**	2001: BioInnovation SA (BioSA) established to accelerate the development and growth of the SA bioscience industry.
		2002: Australian Centre for Plant Functional Genomics established with funds contributed by the SA Government.
		2004: The SA Government launched the SA Strategic Plan, which incorporated targets on R&D and innovation. The *Science, Technology and Innovation Vision 2010* (STI[10]) became SA Government policy.
		2005: First SA Chief Scientist appointed.
2006: NHMRC established as a statutory authority.		2008: $12 million BioSA Incubator launched to promote and accelerate the commercialisation of R&D.
		2009: SAHMRI incorporated as South Australia's first independent health and medical research institute.
	2010-2015	2010: Goyder Institute established.
		2012: Construction started on the Tonsley Innovation District.
		2012: SA Budget introduced a range of measures to support R&D, including: • $780,000 to continue the Australian Centre for Plant Functional Genomics; • $240,000 over two years through the Premier's Science and Industry Fund for innovation; and • the Advanced Manufacturing Strategy.

Key: Research institution Innovation and science precinct Other measure

Australian Government		South Australian Government
	2010-2015	2014: BioSA launched Tech Hub, its second business incubator.
2015: *National Innovation and Science Agenda* (NISA) announced providing funding of $1.1 billion nationally over four years to support 24 measures.		2014: The *Investing in Science Action Plan* became SA Government policy.
	2016-2020	2016: BioSA became TechInSA to promote and accelerate the commercialisation of R&D.
		2016-17 SA Budget announced the *Investment in Innovation* package, including the $10 million SA Early Commercialisation fund, and $7.5 million for the Future Industries Institute.
		2017-18 SA Budget provided: • $44 million for SAHMRI 2; and • $6 million to establish the Australian Institute for Machine Learning (AIML)
		2017-18 SA Budget also provided $4 million to establish a new space innovation hub and build SA's space ecosystem through the Space Innovation Fund.
		2018: Office of the Chief Entrepreneur established.
		2018-19 SA Budget provided: • approximately $1.3 million over four years to establish a new Australian Space Innovation Precinct; and • $44 million in capital works funding. for Lot Fourteen.
2018-19 The Budget announced the *Better targeting the R&D tax incentive* measure.		2018-19 SA Budget also provided $28 million for the Research, Commercialisation and Startup Fund.
2019: Adelaide City Deal secured $672 million of joint Commonwealth and State funding for Lot Fourteen, to include an Entrepreneur and Innovation Centre and Hub to connect research with industry.		
		2019-20 SA Budget provided $19.6 million in NCRIS Investment in SA.
		2020: *EXCITE Strategic Plan 2020-2030* released.

Key: Research institution Innovation and science precinct Other measure

Source: South Australian Productivity Commission research of documents and sources

2.1.2 Current SA Government policy

The SA Government's current economic focus is captured in the *Growth State* plan. Launched in 2019; *Growth State* includes the government's objective to achieve annual economic growth of 3 per cent. It has nine priority sectors: tourism; international education; defence industry; food, wine and agribusiness; hi-tech, health and medical industries; energy and mining; space industry; and creative industries. Each of the nine is the subject of a sector growth plan. Four themes: trade and investment; skills and innovation; infrastructure; and land, water and environment, provide the foundation for the identified growth sectors.

R&D for primary industries and HMR account for 86 per cent of the state's total R&D expenditure through:

- the Department of Primary Industries and Regions (PIRSA), which delivers R&D programs through the South Australian Research and Development Institute (SARDI) and Rural Solutions SA (RSSA); and
- the Department for Health and Wellbeing (DHW), which supports HMR in the state's public health system through policy development, coordination and governance support, and works alongside other SA Health entities that undertake R&D (discussed in the chapter of the HMR inquiry).

Other agencies are involved in R&D-related initiatives in accordance with their statutory responsibilities and the priorities of government. For example, in 2019-20, the Department for Environment and Water (DEW) engaged in, and provided funding for, several environmental research projects. It also runs a research scholarship program and funds the Goyder Institute for water-related research ($2 million per annum).

The Department for Innovation and Skills (DIS) has a lead role in R&D policy in the state. It has broad responsibility for supporting science and strategic initiatives. It also facilitates the state's engagement in Australian Government R&D programs (including those sponsored by NCRIS, the CSIRO and Centres of Excellence and Cooperative Research Centres). The Office of the Chief Scientist and the Office of the Chief Entrepreneur sit within the DIS portfolio.

Grant programs, delivered through the Industry Assistance Framework, are an important element of the SA Government's economic and industry policy. The framework delivers financial assistance to private sector entities through three designated funds:

- Economic and Business Growth Fund ($100 million over four years);
- Regional Growth Fund ($150 million over ten years); and
- Research, Commercialisation and Startup Fund ($28 million over four years).

The Research, Commercialisation and Startup Fund comprises three competitive funding streams:

- Stream 1 – The Strategic Research Initiatives stream supports research initiatives that create innovative solutions or translate research into industry or commercial outcomes which address economy-wide challenges for South Australia. Funding from this stream is awarded through calls for proposals to address specific initiatives. Two such calls have been made. The first of these was made under the Financial Services Development program and sought projects to deliver new products, and solutions to problems in the finance and fintech sectors. The second was made under the South

Australian CRC Assistance Program, to leverage strategic benefits of the Commonwealth CRC Program for South Australia.

- Stream 2 – The Startup and Early Stage Company Incentive stream provides entrepreneurs with funding to start and scale their innovative early-stage business.
- Stream 3 – The Entrepreneurship and Innovation Ecosystem Initiatives stream supports programs, events and activities that have broad benefit to the startup community.

In October 2020, the state government released its EXCITE strategy – a 10-year science and innovation strategy designed to grow business investment in R&D, to drive innovation and to increase productivity in South Australia[5]. The intent is to:

- place South Australia in the top quartile of OECD nations by 2030 for key measures of performance in the research and innovation value chain;
- support the emergence of Adelaide as one of the world's magnet cities; and
- ensure that the growth plans for priority industry sector are underpinned by a high performing research and innovation value chain.

The EXCITE strategy is built on four enabling strategies:

- Excellence of research and innovation outputs through leveraging national funding programs for an increased South Australian share of investment to build excellence at scale;
- Collaboration between the world's best researchers and businesses and between business and research to drive knowledge transfer, by targeted recruitment of global innovators and developing the frameworks required to deliver the 'metrics of success' for innovation precincts;
- Innovation and Translation – delivery of new products, processes and services based on R&D intensity, and the translation of innovation, including commercialisation, through the intermediaries program funded in the budget, and through 'innovation challenges' set by governments; and
- An Enabled Future Workforce – with the skills capability, capacity and diversity to meet the demands of a growth in STEMM and technology-based industries, through early identification of gaps in skills or in future workforce capability and capacity, and by building a more diverse STEMM workforce.

Currently, the EXCITE strategy nominates only categories of potential measures of performance against its four enabling strategies.

The 2020-21 State Budget allocated funding to implement two initiatives of the EXCITE strategy from the existing Economic and Business Growth Fund.

The first provides $7 million over four years to establish Innovation and Translation Intermediaries within South Australia's Innovation Districts and Neighbourhoods. There is a focus on small and medium enterprises to enhance industry-research collaboration and increase knowledge transfer, technology capability, growth in revenue and exports as part of a South Australian Knowledge Transfer Network.

[5] <https://innovationandskills.sa.gov.au/science/excite-strategy>

The second includes $1 million in 2020-21 for an innovation challenge to capture new technologies and facilitate the convergence of research and development across technology domains to support industry sectors and startups gain early market advantage. The challenge will be developed in conjunction with the Chief Scientist and Chief Entrepreneur.

Science and innovation precincts, partnerships and institutions

Science and innovation precincts are a prominent feature of SA Government policy for industry support and innovation. The state operates three major science and innovation precincts – Mawson Lakes Technology Park, Tonsley Innovation District, and Lot Fourteen.

While not exclusively R&D focused (precincts are also commercial hubs, providing commercial leasing and business support); they are a base for government, university and business entities to engage and collaborate in R&D. The operation of these precincts is discussed in detail in the Commission's Draft Report of this inquiry.

The state has a significant presence in the Waite Research Precinct through SARDI and has a presence in Adelaide Biomed City which is a new HMR precinct being developed with funding from the Commonwealth, and is a collaboration between SAHMRI, the University of Adelaide, the University of South Australia, and the Central Adelaide Local Health Network.

The institutes that the state supports directly include SARDI, the Australian Water Quality Centre (AWQC), the Goyder Institute, the Geological Survey of South Australia and SAHMRI.

South Australian Research and Development Institute (SARDI)

SARDI is the state's single largest public research institution, delivering 'science outcomes for public good' in the primary sector[6]. As the research arm of PIRSA, SARDI undertakes applied primary industries, food and wine research and development, including practice change, on behalf of the SA Government. It has 11 facilities across SA and employs approximately 370 on-site staff, predominantly based at the Waite Campus of the University of Adelaide, and at the SA Aquatic Sciences Centre at West Beach. SARDI also undertakes adoption and extension activities with primary industry firms to promote the uptake of research.

Other key institutions and partnerships

Other smaller scale SA Government entities which provide public-facing research services include:

- AWQC, which is an independent business unit of the government-owned enterprise, SA Water; and
- Geological Survey of South Australia (GSSA), which is an authority within the Department for Energy and Mining (DEM).

The SA Government has also maintained long-term institutional partnerships with the Goyder Institute for Water Research, and with the Waite Institute on agricultural research through SARDI's presence at the Plant Research Centre.

Although HMR is outside the scope of this inquiry, the Commission notes the SA Government's main partnership on R&D in the health and medical fields is the South Australian Health and Medical Research Institute (SAHMRI) – the state's flagship independent HMR institute. The Commission understands that DHW provides approximately $5-6 million annually to SAHMRI as an operating grant.

[6] Department of Primary Industries and Regions SA, SARDI Strategic Plan 2018-2023 (2019).

SAHMRI is also a partner in the Adelaide BioMed City precinct which provides an integrated and connected environment where research, teaching, training and clinical services support the delivery of excellence in healthcare. It stimulates innovation and encourages the transition of research discoveries into clinical practice and commercially viable projects.

Expenditure on R&D measures 2015-16 to 2020-2021

Figure 2.2 illustrates the flow of SA Government expenditure from new budget measures committed in the six years from 2015-16 to 2020-21, with expenditure totals grouped by purpose on the right-hand side.

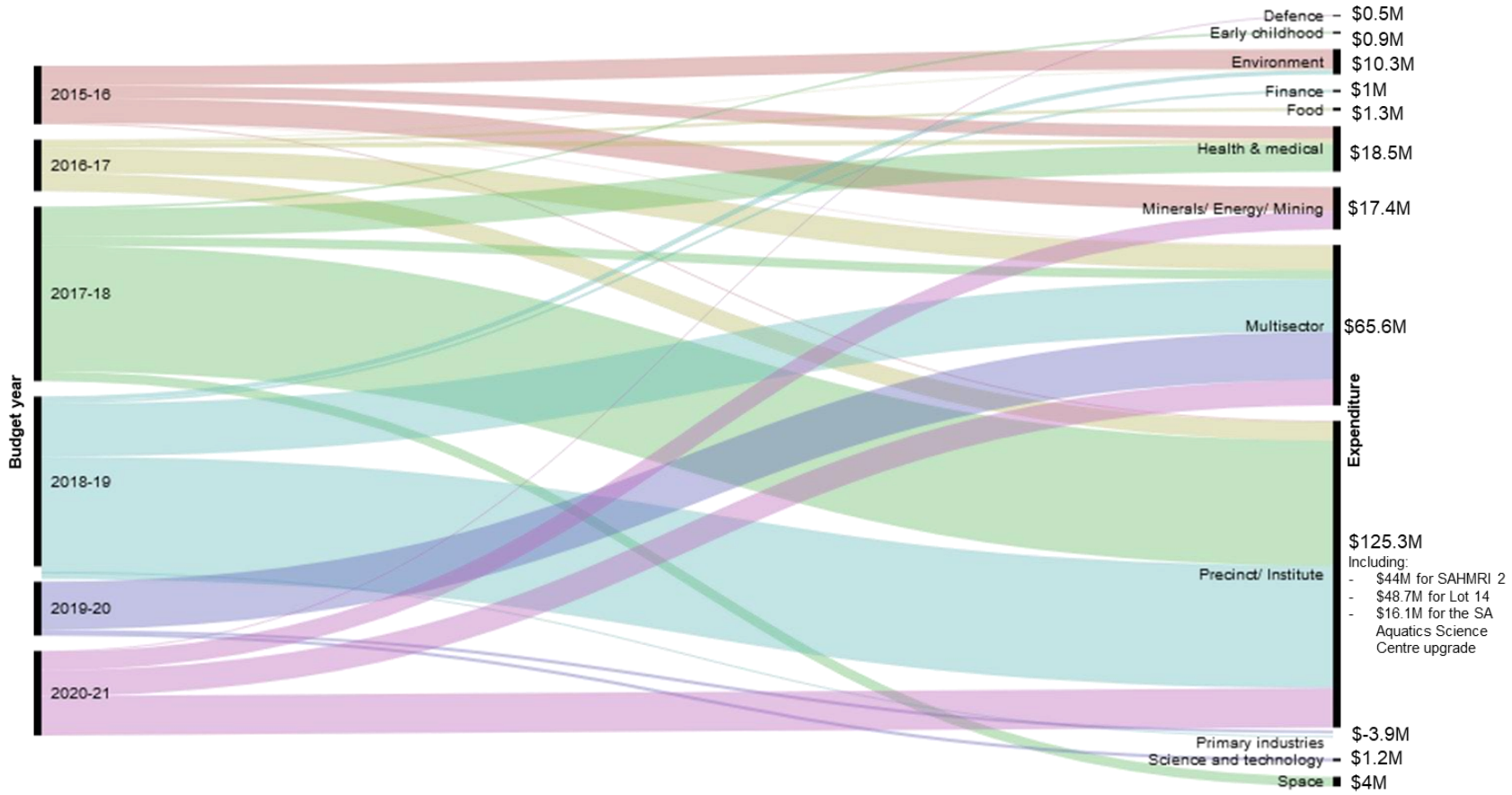
The SA Government committed an estimated $241.9 million[7] in new R&D measures since 2015-16 for R&D-related projects across diverse fields, notably:

- More than half of new funding ($125.3 million) was committed to research institutes and science and technology precincts, including $48.7 million to build Lot Fourteen and $44 million to build SAHMRI 2. Funding has been heavily weighted toward building physical infrastructure.
- Funding of $65.6 million was committed to multisector R&D measures (those that did not target any sector), including establishment of the Research, Commercialisation and Startup Fund ($28 million), and a measure to fund Investment in SA based NCRIS Projects ($19 million).
- The HMR sector received the most of new R&D spending ($18.5 million), with a substantial amount allocated as SAHMRI operational grant funding ($5.1 million allocated in 2015-16)[8].
- The minerals/energy/mining sectors also received substantial funding ($17.4 million) for two R&D initiatives and to establish the CORE research and innovation hub at Lot Fourteen.
- Funding for primary industries R&D was reformed during the period (delivering net savings of an estimated $3.9 million), due to a 2018-19 measure that changed funding and cost recovery arrangements for SARDI. Savings of $5.1 million were partially offset by new investment for a Pulse Cooperative Research Centre, allocated to PIRSA. It should also be noted that primary industries infrastructure spending has been allocated to precincts/ institutes in Figure 2.2, including the 2020-21 Budget measure which committed $16.1 million to upgrade SARDI's SA Aquatic Science Centre.
- The remaining funding ($26.3 million) was spread thinly across R&D initiatives in areas of defence, early childhood, environment, finance, food, space, minerals, energy, and mining, science and technology.

[7] Commission estimate based on an analysis of Budget Measures Papers and Mid-year Budget Reviews from 2015-16 to 2020-21. Only new SA Government funding commitments are included in this amount. It does not include recurrent funding for existing R&D policies and programs or new measure prior to 2015-16. Investment by the Commonwealth in Lot Fourteen through the Adelaide City Deal is not reflected, since this figure reflects SA Government funding commitments.

[8] SAHMRI would also have received recurrent funding during the period, not reflected in the Budget papers.

Figure 2.2: South Australian Government R&D-related new measures from 2015-16 to 2020-21, by purpose ($m)



Source: Commission's estimates based on data drawn from the Department of Treasury and Finance, Budget Measures Statements and Mid-year Budget Reviews for each year.

2.1.3 Evaluations of SA R&D policy

Evaluation is a key tool for facilitating efficient and effective delivery of government services through evidence-based policy and decision-making across the public sector. In an environment of constrained public finances, it is essential that public funds are spent on activities that provide the greatest economic and social return.

During this inquiry, the Commission requested from agencies details of program evaluations with respect to R&D programs and initiatives. Very few evaluations were provided. Consequently, the Commission notes there is very little evidence to demonstrate value for money or the impact of R&D policies and programs through the course of the past twenty years. The past evaluations received are discussed below.

SARDI review

A 2016 review of SARDI looked at the effectiveness of its business model, funding sources and organisational structure. The review found that SARDI maintained a strong reputation for technical excellence and produced significant research at the national and state levels. Nevertheless, it found a lack of alignment between SARDI's research activities and the SA Government's strategic objectives. The review recommended SARDI implement a strategic framework to assess its activities, and increase its focus on post-farmgate research, which SARDI subsequently adopted in its updated *2018-2023 Strategic Plan*.

Evaluation of R&D-related innovation system and business support policy

A few broad evaluations have been conducted on SA's innovation and business support programs relevant to R&D:

- The Redfire Consulting Group completed three evaluation reports for the SA Government on its early-state innovation ecosystem programs over the course of a year. The final report (completed in 2016) identified problems around inefficient administration, a lack of a co-ordinated approach across government, and insufficient data collection on performance[9].
- In 2017, the then Department of State Development commissioned consultant group Econsearch to assess the outcomes of 20 industry and economic development programs delivered by its Innovation, Science and Small Business Division. The evaluation sought to identify meaningful measures of economic impact for individual programs. The evaluation relied heavily on government expenditure, rather than specific outputs, to measure success[10].

The Commission is concerned that the state government does not routinely collect high-quality evaluation information on R&D expenditure, activities and results, and analyse this data to improve programs or identify new opportunities. That means the government is not well placed to respond to fiscal shifts and the longer-term challenges of providing sustainable, high-quality services and supporting economic growth. Structured evaluations are a key source of information on the cost-effectiveness of government activities, for accountability purposes, to improve existing policies and to better design future policies. Greater transparency, accountability and simplicity in policy is needed to ensure that the SA Government investment in R&D delivers maximum impact and value for money.

[9] Redfire Consulting Group, Implementation Plan for a South Australian Commercialisation Fund (2016).
[10] Econsearch, IISSB Industry Programs Outcomes Assessment (2017).

Given the limited amount of evaluation data available, the Commission concludes that the state government needs to reinforce the need for evaluations to be completed on a regular basis and ensure that individuals and agencies accountable for the overarching R&D strategy have access to the evaluation data. This issue will be addressed in more detail through recommendations in Chapter 7.

2.2 Other Australian jurisdictions

Other Australian jurisdictions actively encourage and facilitate R&D and innovation. A selection of programs is presented below.

New South Wales

In late 2019 the Parliamentary Secretary to the Premier was tasked with developing an action plan to accelerate R&D investment. An advisory council was established and is expected to report this year. Chaired by David Gonski, the advisory committee is focused on four state government levers: the government's role as a participant in the innovation ecosystem, attracting and retaining the best talent and investment, fostering collaboration and supporting startups to scale up.

The NSW Physical Sciences Fund (PSF) is a competitive development and commercialisation program for technological innovations. The PSF supports the translation of research into devices and systems ready for commercialisation. The $5 million fund aims to deliver significant social, economic and environmental benefits by providing financial support for the development of new and innovative devices and systems within NSW, across the branches of physical science and engineering, including physics, chemistry, astronomy and the earth sciences.

In 2018 the NSW Government invested $18 million in the Boosting Business Innovation Program, giving small businesses access to research organisations. The program provides access to high tech equipment and technical expertise research by SMEs and startups through a voucher program.

Victoria

In its 2020-21 Budget, the $2 billion Breakthrough Victoria Fund was announced to help support new Victorian jobs, driving investment in research, innovation and the next great breakthroughs over the next 10 years. This investment will focus on priority industries, including medical research, health and life-sciences, agri-food, advanced manufacturing, clean energy and digital technologies.

The Victorian Higher Education State Investment Fund was a response to the significant impact of the coronavirus (COVID-19) pandemic on Victorian universities. The $350 million fund will support universities with capital works, applied research and research partnerships focused on boosting Victoria's productivity and economy as the state recovers from the impacts of the virus[11].

The Victorian Government (through LaunchVic) established the Victorian Innovation Hub at the Goods Shed North. The multi-sector hub brings together specialists including fintech incubator hub Stone & Chalk, agtech accelerator SproutX, Australia's national medtech accelerator The Actuator, and leading technology accelerator Startmate. The CSIRO's digital innovation arm Data61 is also located within the Goods Shed North.

[11] See <https://www.education.vic.gov.au/training/Pages/covid-support-universities.aspx>

CivVic Labs is a pre-accelerator and accelerator program in which startup businesses develop innovative solutions to resolve public sector challenges. Startups have the opportunity to secure up to $150,000 in investment to develop a solution as a market-ready product and impact change on a larger scale.

Queensland

Queensland's research priorities include support for the Advance Queensland Industry Roadmaps, part of the $755 million Advance Queensland program. The Industry Roadmaps support the following industries:

- Advanced manufacturing
- Aerospace
- Biofutures (including synthetic biology)
- Biomedical
- Defence
- Mining equipment, technology and services
- Screen industry
- Agriculture and food.

Queensland has made several strategic investments into science and innovation, firstly through the Smart State Strategy and now through Advance Queensland. Key recent research initiatives include:

- The Advance Queensland Industry-Research Fellowships, supporting researchers to build their careers while collaborating with industry and other end users;
- The University of Queensland's COVID 19 'molecular clamp' vaccine, which has been fast-tracked with the assistance of Queensland Government funding;
- Joint programs and cooperation agreements with overseas research leaders in countries such as China and the United States of America; and
- The Queensland Defence Science Alliance, supporting connections and collaborations between universities, defence industry and government to grow and integrate Queensland's defence capacity and capabilities to support Commonwealth defence objectives and strategy.

2.3 Links to Australian Government policy

The Australian Government is a significant funder of R&D activity nationally. In 2019-20, total expenditure was $9.6 billion. This includes expenditure on research by the Australian Government's own agencies (intramural R&D) and funding paid to other entities (extramural R&D). A table summarising Australian Government investment in R&D by program, by sector, appears in Chapter 3.

Over 70 per cent of Australian Government expenditure on R&D is administered through the Department of Industry, Innovation and Science. The Australian Government's funding objectives for R&D and innovation are contained in several strategic plans and statements. The National Innovation and Science Agenda (NISA) 2015 is one of the most important

overarching statements of the Australian Government's strategic priorities in all areas of R&D and innovation. Other related statements of the government's overarching policy objectives include the National Science Statement and the government's response to the recent *Australia 2030: Prosperity Through Innovation* report.

Outside the higher education sector, Australian Government R&D policy principally relies on three pillars: the R&D Tax Incentive, public R&D institutions, and grant funding. These are briefly discussed below. More detail is provided in the Commission's Draft Report[12].

2.3.1 The R&D Tax Incentive

The R&D Tax Incentive encourages companies to engage in R&D benefiting Australia by providing a tax offset for eligible R&D activities. It has two core components:

- a refundable tax offset for certain eligible entities whose aggregated turnover is less than $20 million; and
- a non-refundable tax offset for all other eligible entities.

The R&D Tax Incentive was reviewed at the launch of the National Innovation and Science Agenda in 2016. The Chair of Innovation Australia, the Chief Scientist of Australia, and the Secretary to the Treasury chaired the review panel. The review looked at ways to improve the R&D Tax Incentive's effectiveness and integrity, including how the focus could be sharpened to encourage additional R&D investment.

The government announced its initial response to the review as part of the 2018-19 Federal Budget. Revised legislation, the Treasury Laws Amendment (Research and Development Tax Incentive) Bill 2019, was introduced into Parliament in December 2019. That legislation has been superseded.

The Australian government announced enhanced reforms to the R&D Tax Incentive as part of the 2020-21 Budget. These changes apply to income years beginning on or after 1 July 2021. Some administrative elements of the reforms will apply from 1 January 2021.

2.3.2 R&D institutions

A few of the national institutions are important in South Australia. The Commonwealth Scientific and Industrial Research Organisation (CSIRO) operates under the provisions of the *Science and Industry Research Act 1949* to carry out research to assist Australian industry and benefit the Australian community. In 2019, CSIRO entered into a Strategic Relationship Agreement (SRA) with the SA Minister for Innovation and Skills, formalising a commitment to work together on R&D initiatives of mutual interest.

The Defence Science and Technology (DST) Group, which is the Australian Government's lead agency responsible for applying science and technology to safeguard Australia's national interests, has a significant R&D presence in SA. Its largest Australian operation is located at Edinburgh in Adelaide, and is home to more than 1,200 scientists, engineers, IT specialists and support staff undertaking military research in areas such as: surveillance systems, autonomous systems, electronic warfare, information systems, propulsion and

[12] South Australian Productivity Commission, Inquiry into Research and Development, Draft Report, September 2020.

energy, weapons effects, human science and operations analysis[13]. It also has a policy for R&D collaboration with partners and industry through the Research Collaboration Security Framework. Defence SA is South Australia's lead government agency responsible for managing SA's relationship with DST Group[14].

Finally, the Australian Government funds rural Research and Development Corporations (RDCs) through the Department of Agriculture, Water and the Environment. There are currently 15 RDCs in operation, comprising 5 Commonwealth statutory bodies and 10 industry-owned companies[15]. Wine Australia is a statutory RDC with a significant presence in South Australia and its head office is in Adelaide. The Fisheries Research and Development Corporation and the Grains Research and Development Corporation are also statutory RDCs with offices in South Australia.

2.3.3 Competitive grant funding

The Australian Government provides direct assistance for R&D activities through a range of competitive grant programs that are detailed in Chapter 3. While much of this funding is directed towards the higher education sector it also benefits private and industry-led R&D entities. The Australian Government's major R&D grant schemes include:

- the National Competitive Grants Program (NCGP) administered by the Australian Research Council (ARC);
- the Cooperative Research Centre Program;
- the National Collaborative Research Infrastructure Strategy (NCRIS); and
- grants for health and medical research through the National Health and Medical Research Council (NHMRC) and the Medical Research Future Fund (MRFF).

2.3.4 Recent program announcements

The 2020-21 Federal Budget includes an investment of $1.5 billion over four years for the Modern Manufacturing Strategy (MMS) which provides an opportunity for SA to work with the Australian Government.

The MMS includes the $1.3 billion Modern Manufacturing Initiative (MMI). The MMI will support projects within six National Manufacturing Priorities: resources technology and critical minerals processing, food and beverage, medical products, recycling and clean energy, defence, and space.

The MMI will be delivered in 3 streams – collaboration, translation, and integration. The collaboration stream will assist very large projects which support business-to-research collaboration to build economies of scale. The translation stream will help manufacturers translate good ideas into commercial outcomes. It will also encourage investment in non-R&D innovation. Specific details of the MMI will be released in the course of 2021.

[13] Defence SA, Defence Science and Technology, (Web Page, undated) <https://defencesa.com/projects/research-and-development/>
[14] Department of Defence, Defence Research Collaboration Security Framework (2020) <https://www.dst.defence.gov.au/partner-with-us/defence-research-collaboration-security-framework>
[15] 'Rural Research and Development Corporations', Department of Agriculture, Water and Environment (Web Page, February 2020) < https://www.agriculture.gov.au/ag-farm-food/innovation/research_and_development_corporations_and_companies>

2.4 Links to the higher education sector

SA's three major higher education institutions — the University of Adelaide, Flinders University, and the University of South Australia (UniSA) — are significant in the R&D sector in South Australia. Table 2.1 summarises the research focus of the three universities. The universities are active participants in both Commonwealth and state R&D initiatives, while also undertaking their own research.

Table 2.1 South Australian universities and their current areas of research

Organisation	Research focus	Locations
University of Adelaide	The principal foci are: • photonics and advanced sensing; • mineral energy and resources; • machine learning; • agriculture, food and wine; • human reproduction and clinical health; • material characterisation and fabrication; and • genetic science and plant genomics.	There is the SA Health and Biomedical Precinct at North Terrace, the Waite campus and the Roseworthy campus. The University has numerous specialist research centres working across many industry sectors and is a host and partner of several National Centres of Excellence (hosting the CRCs on high integrity Australian pork and fighting food waste).
University of South Australia	The University of South Australia aims to build research capability positioned around six key themes that respond to some of the most pressing needs of society: • an age-friendly world; • transforming industries; • cancer prevention and management; • scarce resources; • healthy futures; and • society and global transformation.	The research themes are interdisciplinary and seed research activities that span existing schools and divisions. UniSA has research and industry alliances with: the Centre for Cancer Biology; the Alliance for Research in Exercise, Nutrition and Activity; the Australian Centre for Asian Business; the Centre for Tourism and Leisure Management; and Industrial AI. UniSA also hosts a Centre of Excellence on Cell Therapy Manufacturing.
Flinders University	Research is undertaken across all areas in the institution's six colleges: medicine and public health; nursing and health sciences; science and engineering; business, government and law; humanities, arts and social sciences; education, psychology and social work.	The Tonsley precinct houses: • the Australian Industrial Transformation Institute, undertaking trans-disciplinary industry and workplace research in support of industrial and workplace transformation; and

Organisation	Research focus	Locations
	Areas of research strength are located in a number of research institutes and centres. Areas of research strength include: • health and medical research; • nanotechnology; • industry 4.0 research, focussing on DST and defence industry collaborative research programs; • archaeology and history, with particular strength in maritime and indigenous archaeology; • ecology with a focus on palaeontology; • marine science research; • water research; • medical engineering research; • security and resilience research; and • creative arts research.	• the Institute of Nanoscale Science and Technology, a hub of nanotechnology research and education. The precinct is also home to technology-focussed health and medical research capability, including the Medical Devices Research Institute, the Medical Devices Partnering Program (MDPP) and the Flinders Digital Health Research Program.

Source: South Australian Productivity Commission summary of university documents and websites

The Australian Government funds R&D in the higher education sector nationally through research block grants as well as competitive grants awarded mainly through the National Health and Medical Research Council, the Medical Research Future Fund and the Australian Research Council. While university policy and funding are principally governed by the Commonwealth, South Australian public universities are established by State legislation:

- *University of Adelaide Act 1971;*
- *Flinders University Act 1966;* and
- *University of South Australia Act 1990.*

These Acts also set out the universities' governance and reporting arrangements.

2.5 Conclusion

R&D strategy in South Australia exists in a complex eco-system involving many different institutions, policies and programs, delivered by both the Australian and state governments. Compared to the Australian Government, the state government is a small player in R&D expenditure.

Over decades the state has funded R&D through programs, projects, real property and institutions. Figure 2.1 shows a considerable amount of policy activity initiated by the state,

but the Commission notes that there has also been a lot of churn with, programs being short-lived, measures being adjusted, and spending being regularly redirected.

The Commission is particularly concerned that evaluation strategies and the necessary data capture for monitoring and evaluation are rarely considered when initiatives are designed and developed. Measures, monitoring and evaluation are not only essential components of an accountable R&D system but also form part of the foundation for an evidence-based whole-of-state government strategy for raising the level and contribution of R&D. Such information enables the impact of initiatives to be understood and inform future policy development.

Not surprisingly, given the lack of focus on evaluation and data capture, the Commission has found little evidence that the SA government policies and projects have had a measurable impact on the state's economic performance. In Chapter 7, the Commission makes recommendations that address the issues of measuring and reporting on the performance of R&D policy.

3. R&D Funding and Expenditure

This chapter analyses the available information on funding of, and expenditure on, R&D in SA. It provides comparisons between SA and other jurisdictions.

Box 3.1 Sources of data on R&D funding and expenditure

The Commission's capacity to build the picture of the R&D sector in South Australia has been limited by the range and quality of the available data. The Australian Bureau of Statistics (ABS) provides the broadest range of data on R&D in Australia, covering the business, higher education, government and private non-profit sectors. The ABS use the Frascati Manual[16] to define R&D and each sector definition is based on where and by whom the R&D activity is performed. For example, government funding for universities is included in higher education expenditure and government support for business R&D activities is included in business expenditure.

For sectors other than higher education, the ABS only publish total expenditure at the state level as more detailed information comes from surveys with insufficient responses in South Australia for meaningful analysis. As a result, the Commission has in these cases presented national expenditure data.

In addition to the ABS data, the Commission used a range of expenditure data from the Australian Government's Science Research and Innovation (SRI) Budget Tables, the Higher Education Research Data Collection, the Australian Research Council, and other sources. The Commission also requested data from South Australian Government agencies. Unlike the ABS information, this data often includes all expenditure by the sector from where the money was provided. For instance, the R&D tax offset is included in the SRI Budget Tables, and grants to universities are listed as a government expense.

Furthermore, while there have been previous analyses of South Australian Government expenditure on R&D, agencies have no requirement to regularly report their R&D expenditure. While agencies have assisted the Commission in identifying their expenditure, data was not available for all years for some agencies and it is likely that some R&D expenditure has been omitted.

These sources of data are not directly comparable due to their different methodologies, but the Commission presents both to gain a comprehensive picture of the R&D sector in South Australia.

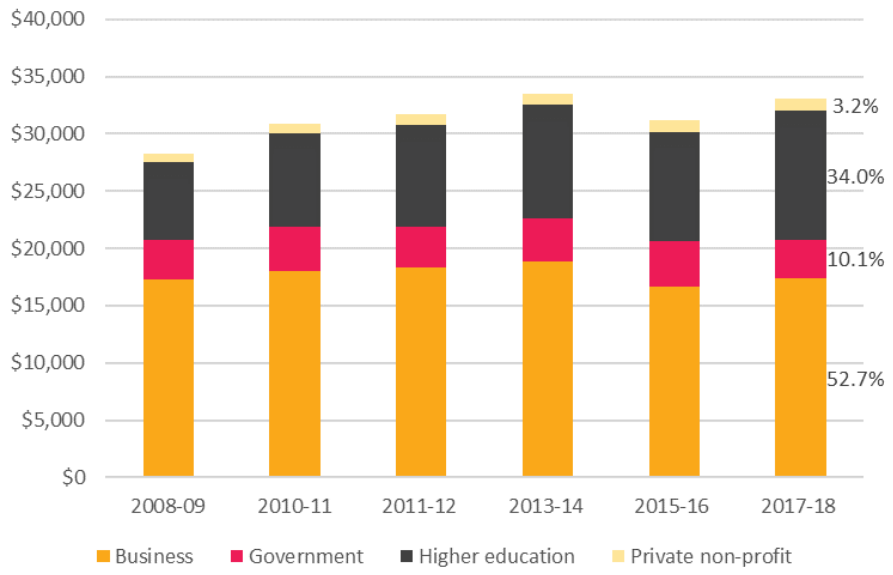
For Australia as a whole, business expenditure on R&D (BERD) accounts for over half of national R&D expenditure (52.7 per cent in 2017-18), followed by higher education expenditure on R&D (HERD) (34.0 per cent). Figure 3.1 shows the shares in national spending from 2007-08 to 2017-2018.

It is not possible to recreate this breakdown of expenditure by sector at the state level due to differing reporting periods and frequency of collection. In South Australia, for the most recent

[16] OECD, Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development: The Measurement of Scientific, Technological and Innovation Activities (OECD Publishing, Paris, 2015).

year for which data is available in each category, governments spent $455 million on R&D, universities spent $827 million and businesses spent $798 million[17].

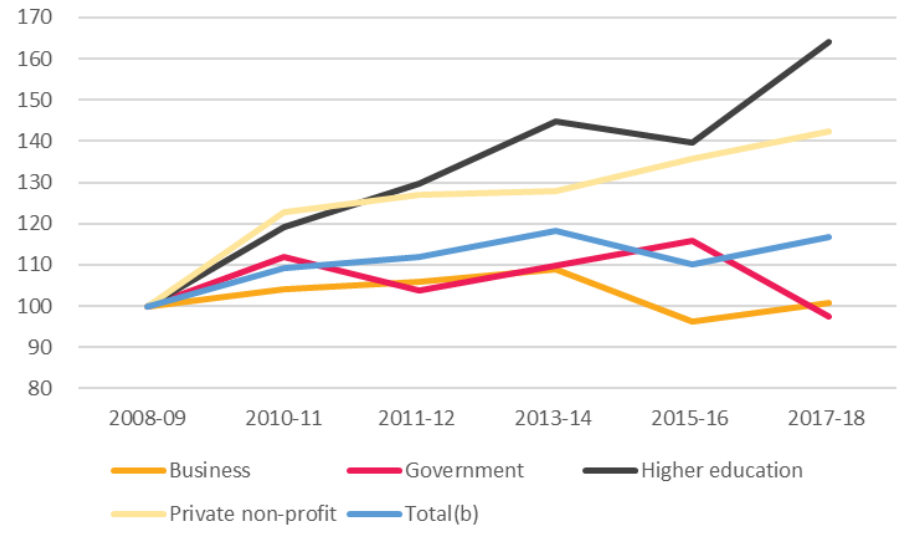
Figure 3.1: Gross expenditure on R&D by sector, Australia ($m, 2008-09 to 2017-18)



Source: ABS 8104.0

The Commission uses measures of intensity of R&D effort as one basis for comparing South Australia to other states and jurisdictions. R&D intensity refers to the relative level of R&D activity within the economy (e.g. the ratio of R&D expenditure to Gross State Product (GSP). South Australia has relatively lower levels of business and private non-profit expenditure on R&D as a proportion of GSP than Australia as a whole, and higher levels of government expenditure in R&D.

Figure 3.2: Change in R&D expenditure by type, Australia (Index 2008-09 = 100)



Source: ABS 8104.0

[17] These values are for different time periods, including 2018-19, 2018 and 2017-18 respectively, and cannot be compared directly.

Higher education expenditure on R&D has been the fastest growing expenditure category since 2008-09, as shown in Figure 3.2, growing on average by 5.7 per cent per annum. Government and business expenditure have changed little over this period. While private non-profit is the second fastest growing expenditure category, it represents only 3.2 per cent of national R&D expenditure, and only 2.3 per cent occurs in South Australia.

3.1 Australian Government

While the Australian Government publishes detailed estimates of its total expenditure on R&D as part of its Science, Research and Innovation Budget Tables[18], only the total expenditure is available by state.

In 2018-19, approximately 16 per cent of Australian Government expenditure on R&D occurred in South Australia, as shown in Table 3.1, which was second to Victoria. While more detailed expenditure is not available at the state level, the Commission understands that a large proportion of this higher expenditure in South Australia is likely due to the significant presence of DST in South Australia.

Table 3.1: Australian Government expenditure on R&D by location, $m, 2006-07 to 2018-19

Location	2006-07	2008-09	2011-12	2012-13	2014-15	2016-17	2018-19	Trend
Australian Capital Territory	423	436	492	416	411	367	331	
New South Wales	368	470	396	434	391	351	312	
Northern Territory	18	33	44	34	45	37	36	
Overseas	5	4	19	7	43	32	6	
Queensland	190	193	261	267	257	244	262	
South Australia	302	308	386	352	296	329	340	
Tasmania	113	119	130	127	125	124	142	
Victoria	528	555	586	590	549	529	544	
Western Australia	98	137	113	117	140	125	138	
Total	**2,046**	**2,252**	**2,426**	**2,345**	**2,257**	**2,139**	**2,110**	

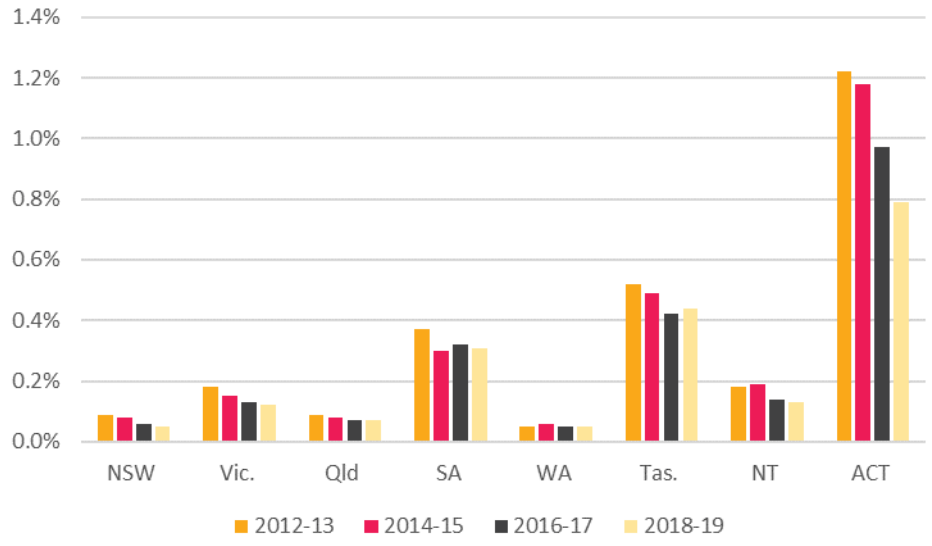
Source: ABS 8109.0

Since 2006-07, intramural Australian Government expenditure on R&D in South Australia has increased by 12.6 per cent, higher than the increase in total expenditure (3.2 per cent). This reflects a shift in expenditure away from New South Wales (15.5 per cent decrease) and the Australian Capital Territory (21.8 per cent decrease).

The intensity of Australian Government expenditure on R&D for each state and territory is presented in Figure 3.3.

[18] Department of Industry, Innovation and Science, 2018-19 Science, Research and Innovation Budget Tables

Figure 3.3: Australian Government expenditure on R&D, by location, per cent of GSP, 2012-13 to 2018-19



Source: ABS 8109.0

When compared to the size of the state's economy, only the ACT and Tasmania have a higher intensity of Australian Government expenditure on R&D. The intensity of Australian Government expenditure on R&D has been declining in all states and territories.

The Australian Government's total expenditure on R&D, both intramural and extramural, by portfolio is presented in Table 3.2.

Table 3.2 Australian Government Investment in R&D, by government portfolio, Australia, 2019-20, $m

Portfolio	$m	% of total
Industry, Innovation and Science	3,662.4	38.0
Education and Training	3,117.6	32.4
Health	1,405.6	14.6
Defence	476.5	4.9
Environment and Energy	432.3	4.5
Agriculture and Water Resources	378.0	3.9
Foreign Affairs and Trade	101.5	1.1
Social Services	39.6	0.4
Veterans' Affairs	9.4	0.1
Home Affairs	5.1	0.1
Prime Minister and Cabinet	4.8	0.1
Treasury	1.8	0.0
Infrastructure, Regional Development and Cities	1.2	0.0
Jobs and Small Business	0.1	0.0
Communications and the Arts	0.0	0.0
Human Services	0.0	0.0
Total	**9,635.8**	**100.0**

Source: Department of Industry, Innovation and Science, 2019-20 Science, Research and Innovation Budget Tables

Over 70 per cent of the Australian Government's expenditure on R&D is administered through the Department of Industry, Innovation and Science and the Department of Education and Training.

Since 2009-10, expenditure on R&D by the Department of Industry, Innovation and Science has declined as a proportion of total Australian Government expenditure from 46.8 per cent to 38 per cent as a result of growth in other areas, with the department's expenditure in 2019-20 approximately the same as 2009-10.

In absolute terms, the Department of Health had the largest increase in R&D expenditure ($603 million) since 2009-10, followed by the Department of Education and Training ($440 million). In percentage terms, the Department of Social Services has increased its expenditure on R&D by more than 20 per cent per year since 2009-10.

Australian Government R&D programs valued at over $100 million are presented in Table 3.3.

Table 3.3: Australian Government R&D programs and activities valued over $100 million, 2019-20

Program/activity	$ Million	Per cent
R&D Tax Incentives – Refundable	1,732.0	19.7
Research Training Program	1,036.3	11.8
Research Support Program	902.1	10.3
NHMRC Research Grants	868.6	9.9
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	839.2	9.6
Australian Research Council (ARC) – National Competitive Grants Program	791.3	9.0
Defence Science and Technology Group (DST Group)	468.3	5.3
Medical Research Future Fund (MRFF)	392.7	4.5
R&D Tax Incentives – Non-Refundable	280.0	3.2
Australian Nuclear Science and Technology Organisation (ANSTO)	257.8	2.9
Australian Renewable Energy Agency (ARENA)	230.3	2.6
National Institutes Program – Australian National University Component	205.5	2.3
Geoscience Australia	192.3	2.2
Cooperative Research Centres Programme	184.3	2.1
National Collaborative Research Infrastructure Strategy	181.9	2.1
Australian Antarctic Division	118.0	1.3
Australian Centre for International Agricultural Research (ACIAR)	101.5	1.2
Total	**8,782.1**	**100.0**

Source: Department of Industry, Innovation and Science, 2019-20 Science, Research and Innovation Budget Tables

The largest Australian Government R&D programs include the R&D Tax Incentive programs ($2 billion in 2019-20) and competitive grants for research[19] ($2 billion), support for higher education research and research training ($1.9 billion) as well as expenditure on R&D by Australian Government bodies such as CSIRO, DST and ANSTO.

CSIRO represents 40 per cent of Australian Government intramural expenditure on R&D, with DST representing a further 22 per cent.

[19] Including NHMRC, ARC, MRFF

Rural Research and Development Corporations (RDCs) are major funders of agricultural R&D, with a focus on applied work to drive agricultural productivity. The RDCs are funded primarily by statutory R&D levies (or charges) on various commodities, with matching funding from the Australian Government.

Since their introduction in 1989, RDCs have provided a significant amount to state government agencies across Australia to conduct R&D. RDCs are the largest funding source of SARDI, providing approximately $30 million annually. RDCs also fund research at universities, funding $141 million of South Australian universities research expenditure over the ten years to 2018.

The Australian Government is currently considering modernising the RDC framework.

The Australian Government's largest investment in R&D is in universities for the general advancement of knowledge (29.6 per cent), as shown in Table 3.4. Other significant investments include industrial production and technology (18 per cent) and health (15 per cent).

Table 3.4: Australian Government investment in R&D by socio-economic objective, 2019-20

Socio-economic objective	2019-20 ($m)	% of total
Exploration and exploitation of the earth	470.54	4.9
Environment	301.02	3.1
Exploration and exploitation of space	57.80	0.6
Transport, telecommunications and other infrastructures	268.35	2.8
Energy	518.13	5.4
Industrial production and technology	1,576.95	16.4
Health	1,661.63	17.2
Agriculture	779.78	8.1
Education	41.43	0.4
Culture, recreation, religion and mass media	34.82	0.4
Political and social systems, structures and processes	553.39	5.7
General advancement of knowledge: R&D financed from General University Funds (GUF)	2,143.84	22.2
General advancement of knowledge: R&D financed from other sources than GUF	712.18	7.4
Defence	515.97	5.4
Total	**9,635.83**	**100.0**

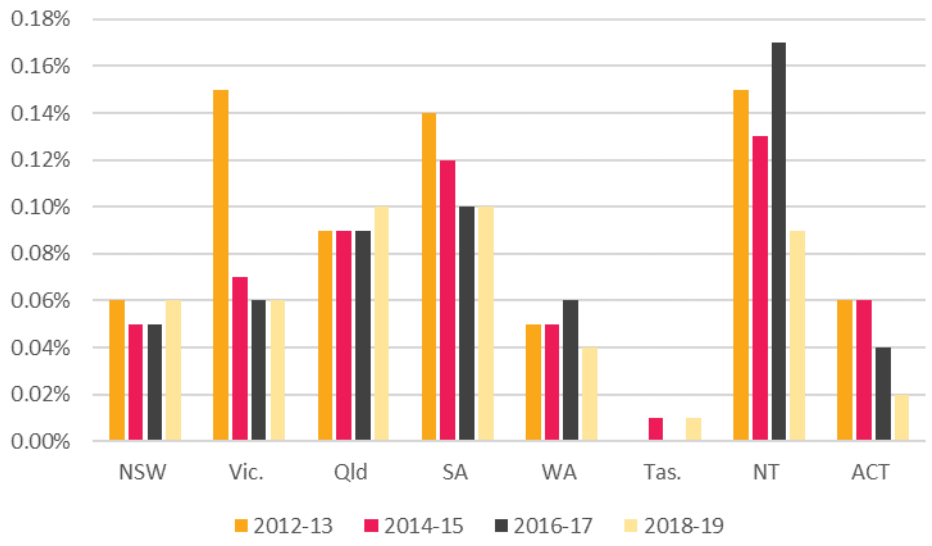
Source: Department of Industry, Innovation and Science, 2019-20 Science, Research and Innovation Budget Tables

Over the past 10 years, the Australian Government has increased its total investment on R&D by 15.8 per cent. During this time, there has been a significant increase in expenditure for health R&D (up $620 million or 59.6 per cent) and the general advancement of knowledge, both from general university funds (up $630 million or 41.6 per cent) and other sources (up $258 million or 56.7 per cent). While expenditure on education has almost doubled over this period, it remains less than half a per cent of total expenditure, and political and social systems, structures and processes expenditure has increased 80 per cent. However, there have been significant decreases in expenditure on industrial production and technology (down $485 million or 23.5 per cent) and culture, recreation, religion and mass media (down $155 million or 81.6 per cent).

3.2 State government

The intensity of state and local government expenditure on R&D for each state and territory is presented in Figure 3.4.

Figure 3.4: State and local government expenditure on R&D as a per cent of GSP, by location



Source: ABS 8109.0

In 2018-19, state and local governments spent $115 million on R&D in South Australia. This accounts for 0.1 per cent of GSP, which was the equal highest intensity of any state in 2018-19. That said, state and local government expenditure on R&D as a proportion of GSP has been declining in all states except Queensland and New South Wales in recent years.

The ABS only report total expenditure by state governments by the state where the activity occurred. Further details of the sources of this expenditure and the types of research are only available aggregated for all states and territories. State and territory government expenditure on R&D by source of funds for all states and territories is presented in Table 3.5.

Table 3.5: State/territory government expenditure on R&D, by source of funds, all states and territories, 2016-17

Source of funds	$'000	Per cent
Own funds	601,660	49.3
Other Australian government	183,212	15.0
Other state and local government	127,227	10.4
Private non-profit organisations	99,537	8.2
Business	77,328	6.3
Joint business and government	97,544	8.0
Universities	13,893	1.1
Donations and bequests	4,331	0.4
Other Australian	3,010	0.2
Overseas	11,620	1.0
Total expenditure on R&D	**1,219,362**	**100.0**

Source: ABS 8109.0

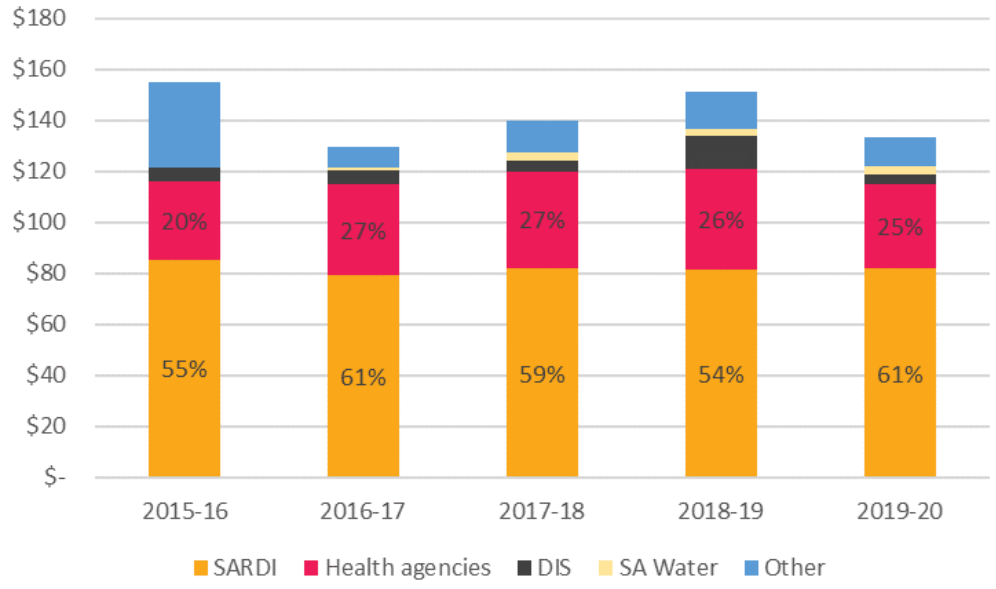
Across Australia, almost half (49.3 per cent) of state and territory government expenditure on R&D is financed solely by the agency conducting the R&D, with a further 10.4 per cent funded by either other agencies, or other state and local governments.

Almost 20 per cent of state government expenditure on R&D is either financed by business (7.7 per cent) or in partnership with business (11.9 per cent).

The South Australian Government does not publish or record its R&D expenditures. The Commission asked South Australian Government agencies to identify and report their expenditures on R&D. This includes expenditure on both intramural and extramural R&D. A previous analysis of the South Australian Government's intramural expenditure on R&D, conducted by the South Australian Government for the periods of 2011-12 to 2014-15, was also provided to the Commission.

Over half of the South Australian Government's expenditure on R&D is spent by PIRSA and SARDI ($82 million or 53.8 per cent of expenditure in 2018-19). Health agencies including DHW, CAHLN, NALHN, WCHN, SCSS and the Lifetime Support Authority represented the second highest expenditure ($39.73 million or 26.3 per cent in 2018-19), as shown in Figure 3.5.

Figure 3.5: South Australian Government identified expenditure on R&D, by agency, $m, 2015-16 to 2019-20



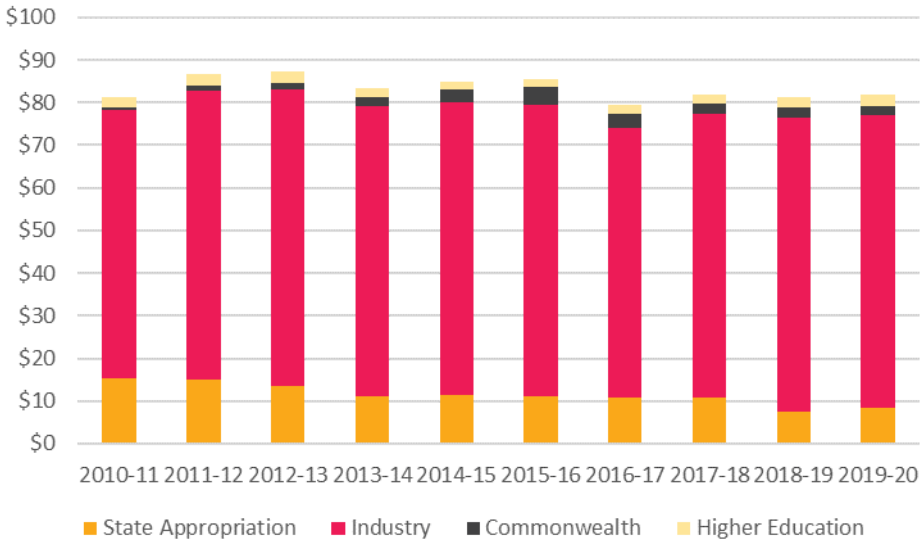
Source: Agency data requests[20]

While SARDI represents over $80 million in expenditure on R&D per year, SARDI raises significant funding from industry and other partners, as shown in Figure 3.6. A large portion of this co-investment is made through RDCs (approximately $30 million annually). State government revenue represents approximately one sixth of this expenditure[21]. State government base funding for SARDI has decreased significantly from a peak of

[20] This data represents only expenditure identified to the Commission and is unlikely to represent all expenditure and some agencies were unable to provide expenditure for certain years. For instance, the Women and Children's Health Network did not report expenditure in 2019-20 and several agencies did not report expenditure prior to 2017-18.
Health agencies were defined as each of the health networks, DHW and the Lifetime Support Authority.
[21] Information provided to the Commission by PIRSA.

approximately $25 million in 2007-08 to $8 million currently. In addition to this base funding, PIRSA provides additional funding for use of SARDI services on a cost-recovery basis.

Figure 3.6: SARDI R&D expenditure, by source of funds, $m, 2010-11 to 2019-20



Source: Agency data requests

Health agencies, including the health networks, DHW, Statewide Clinical Support Services and the Lifetime Support Authority, represent the next most significant expenditure on R&D while DIS expenditure largely consists of grants to bodies outside of government rather than for R&D directly conducted by itself.

The Commission has been unable to quantify the extent to which South Australian Government expenditure on R&D is financed from its own budgets, Australian Government funding, businesses or other sources.

State and local government expenditure overwhelmingly funds operating expenditure, with 6.4 per cent of expenditure going to capital items.

Identified expenditures by agency over the past five years are presented in Table 3.6. This information does not necessarily represent all expenditure and some agencies were not able to provide data for every year. Some of this expenditure is in the form of grants to businesses and universities as well as contracted research to universities. These expenditures would be classified as either HERD or BERD by the ABS. It is also possible that some of this expenditure may not meet the definitions of R&D as defined by the Frascati Manual.

Table 3.6: South Australian Government identified expenditure on R&D by agency, $'000

Agency	2015-16	2016-17	2017-18	2018-19	2019-20
Attorney General's	50	646	50	202	247
Central Adelaide Local Health Network	15,587	18,540	19,280	21,002	17,911
Child Protection				20	102
Correctional Services	81	110	468	528	599
Defence SA	0	50	815	940	1,089
Energy and Mining	28,667	753	920	1,339	493
Environment and Water	2,380	2,365	2,500	3,605	5,231
Human Services		330	1,650	3,349	570
Health and Wellbeing	180	2,073	2,255	1,205	1,275
Innovation and Skills	5,486	5,297	4,289	12,507	4,075
Premier and Cabinet	0	0	2,000	0	0
Treasury and Finance	1,390	940	897	939	49
Trade and Investment	0	0	325	750	450
Forestry SA			725	500	500
Green Industries SA	155	845	36	823	274
Lifetime Support Authority	840	875	1,919	1,552	2,019
Northern Adelaide Local Health Network	660	1,036	848	1,695	1,847
Recreation, Sport and Racing			105	586	133
Primary Industries and Regions SA	660	1,129	856	612	924
South Australian Fire and Emergency Services	286	296	305	315	325
Southern Adelaide Local Health Network	3,714	3,498	4,125	4,497	4,933
South Australian Research and Development Institute	85,388	79,348	81,836	81,369	81,878
SA Water		1,189	2,978	2,962	3,061
Statewide Clinical Support Services	7,317	6,969	6,070	6,374	4,853
TAFE SA	7	778	578	229	485
Women's and Children's Health Network	2,189	2,554	3,695	3,400	
Total	**155,037**	**129,620**	**139,524**	**151,301**	**133,323**

Source: Agency data requests, SAPC calculations

Generally, this expenditure includes expenditure on: intramural R&D; purchases of R&D from other bodies such as universities or other research institutes; purchases of infrastructure or significant research assets; and grants or other support for businesses. The Commission has not been able to quantify the amount of each type of expenditure. Most agencies' expenditure is largely targeted at core functions of the agency, such as purchasing research to inform policy or to review existing policies.

The Department for Innovation and Skills provides most of the South Australian Government's competitive grants to businesses and universities for R&D. They include the Premiers Research and Industry Fund, the Research Commercialisation and Startup Fund, the Medical Devices Partnering Program (MDPP) and the Photonics Catalyst Program.

Further significant R&D support to universities is offered on an ad hoc basis including supporting NCRIS bids. These grants in total have averaged over $6 million over the past ten years.

As shown in Table 3.6, the reported state government expenditure on R&D is $133 million in 2019-20 (not including the $5.9 million SAHMRI grant). After removing the external sources of funds, the balance funded by the state government is of the order of $26 million in 2019-20 (see Table 3.7)[22] In addition, once SARDI base funding and the DIS grant programs are excluded, the balance of $14 million was expended by individual agencies in relatively small amounts that vary substantially from year to year. It is also worth noting that the DIS grants represent most of the funds allocated in a competitive manner.

Table 3.7: SA Government expenditure on R&D ($m)

Year	2015-16	2016-17	2017-18	2018-19	2019-20
Total state R&D expenditure	**155.0**	**129.6**	**139.5**	**151.3**	**133.3**
Non-state-controlled funding					
SARDI					
• Industry Funds and RDC	68.4	63	66.8	69	68.7
• Australian Government funding	4.3	3.5	2.4	2.2	2.1
• Higher education funding	1.6	1.9	2	2.6	2.7
SubTotal SARDI non controlled funds	**74.3**	**68.4**	**71.2**	**73.8**	**73.5**
Health agency expenditure excluding SAMRI grant	25.2	30.0	32.6	34.0	26.9
Forestry SA Community Service Obligation (CSO) expenditure	0	0	0.7	0.5	0.5
GISA (Solid Waste Levy)	0.2	0.8	0	0.8	0.3
Defence SA (Australia Gov. funding)	0	0.1	0.8	0.9	1.1
SA Water funded through customers	0	1.2	3.0	3.0	3.1
GISA funded through specific purpose levy	0.8	0.9	1.9	1.6	2.0
SubTotal other non-controlled Funds	**26.2**	**33**	**39**	**40.8**	**33.9**
State Controlled Funds	**54.6**	**28.2**	**29.2**	**36.7**	**25.9**
Comprised of:					
SARDI	11.1	10.9	10.6	7.6	8.4
DIS	5.5	5.3	4.3	12.5	4.1
Other	38.0	12.0	14.3	16.6	13.4
SAMHRI operating grant (not included in state expenditure)	5.30	5.5	5.6	5.7	5.9

Source: Agency data requests, SAPC calculations

[22] The Commission has tried to exclude all funding from external sources but it is relying on the information provided by agency submissions which may not have included smaller grants.

A previous analysis by the South Australian Government found that the South Australian Government's aggregate level of intramural expenditure on R&D increased by 28.5 per cent (to $135 million) over the 10-year period to 2012-13[23]. However, it does not appear to have increased significantly since then, although the Commission has been unable to separate intramural and extramural expenditure.

Machinery-of-government changes since 2011-12 make comparisons of expenditure by agency over time problematic. There has been a decline in the level of expenditure on R&D by health agencies over this time period, with CAHLN for example spending over $42 million in 2011-12, more than all health entities combined in 2018-19 ($39.7 million).

3.3 Higher education

In 2018, 6.8 per cent, or $827 million, of Australia's higher education expenditure on R&D occurred in South Australia, as shown in Table 3.8. This expenditure has been growing by less than the Australian average and as a result South Australia's share of national expenditure has fallen from 7.4 per cent in 2008 to 6.8 per cent in 2018.

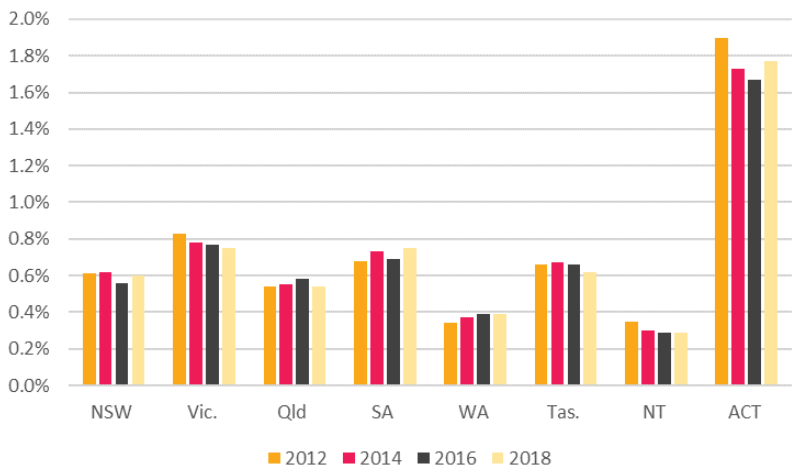
Table 3.8: Higher education expenditure on R&D, by location, $m and per cent growth

State	2008	2010	2012	2014	2016	2018	CAGR[24] (%)
NSW	2,031	2,389	2,909	3,161	3,226	3,762	6.4
Vic.	1,900	2,214	2,782	2,820	3,142	3,430	6.1
Qld	1,061	1,480	1,557	1,668	1,918	2,000	6.5
WA	662	670	845	929	984	1,123	5.4
SA	505	545	640	724	707	827	5.0
ACT	509	682	649	602	633	736	3.8
Tas.	129	130	162	173	193	202	4.6
NT	46	50	66	69	73	79	5.5
Australia	6,844	8,161	9,610	10,145	10,878	12,158	5.9

Source: ABS 8111.0

Each state's higher education R&D intensity is presented in Figure 3.7.

Figure 3.7: Higher education expenditure on R&D, by location, per cent of GSP



Source: ABS 8111.0

[23] Information provided by the Office of the Chief Scientist submission.
[24] Compound annual growth rate (CAGR)

South Australia had the equal second highest intensity of higher education R&D with higher education expenditure on R&D equal to 0.75 per cent of GSP in 2018.

The largest sources of funds for R&D by universities in South Australia are general university funds and Australian Government funding for R&D, as demonstrated in Table 3.9.

Table 3.9: Higher education expenditure on R&D, by source of funds, by location, 2018

Source of funds	South Australia		Australia		South Australia's share of national
	$m	%	$m	%	%
Australian competitive grants	145	17.5	1,774	14.6	8.1
General university funds	354	42.9	6,823	56.1	5.2
Other Australian government	195	23.5	1,891	15.6	10.3
State and local government	36	4.3	457	3.8	7.8
Business	49	6.0	522	4.3	9.5
Donations, bequests and foundations	18	2.2	301	2.5	6.0
Overseas	30	3.6	390	3.2	7.6
Total	**827**	**100.0**	**12,158**	**100.0**	**6.8**

Source: ABS 8111.0

General university funds are the largest source of funding for R&D expenditure (42.9 per cent of South Australian HERD in 2018). Compared to the national total, general university funds make up a smaller proportion of South Australian universities' expenditure on R&D and they are more reliant on Australian Government grant funding. The Commission understands that one of the largest sources of discretionary funds available for universities to spend on R&D is surplus revenue from international student fees.

A 2016 study by Deloitte Access Economics[25] found that on average across Australia the cost of teaching in universities was only 85 per cent of the funding for a Commonwealth supported place, with the remainder cross-subsidising other functions including research.

Fees for international students exceed those of Commonwealth supported places meaning that revenue from international students becomes a significant source of discretional funding for universities. One recent estimate suggests that nationally 27 per cent of university research is funded by surpluses from international students[26].

The National Health and Medical Research Council provided over 40 per cent of South Australian universities' competitive grants in 2018, with the Australian Research Council (ARC) providing a further 30 per cent and Rural Research and Development Corporations providing a further 15 per cent.

South Australia's share of national expenditure by source of funding and the growth rate of each is presented in Table 3.10.

[25] Deloitte Access Economics, Cost of Delivery of Higher Education, (2016), Final Report, p. xxii
[26] A Norton, How reliant is Australian university research on international student profits? (2020), Blog post, < https://andrewnorton.net.au/2020/05/21/how-reliant-is-australian-university-research-on-international-student-profits/>

Table 3.10: South Australia's share of national higher education expenditure on R&D by source of funding, 2006 and 2018

Source of funding	SA share of national (%)		Compound annual growth rate (%)	
	2006	2018	AUS	SA
Australian competitive grants	8.9	8.1	5.0	4.3
General university funds	6.0	5.2	7.4	6.2
Other Australian government	10.8	10.3	7.9	7.4
State and local government	8.7	7.8	6.7	5.7
Business	5.8	9.5	3.8	8.1
Donations, bequests and foundations	8.5	6.0	13.7	10.4
Overseas	5.9	7.6	7.9	10.3
Total	**7.3**	**6.8**	**6.9**	**6.3**

Source: ABS 8111.0

Since 2006, despite growing at an average annual rate of 4.3 per cent, Australian Government competitive grants have decreased from 22.1 per cent of South Australian higher education expenditure on R&D to 17.5 per cent in 2018. Over this same period other Australian Government funding, which includes support for indirect costs of R&D, as well as the purchase of research, increased from 20.9 to 23.5 per cent.

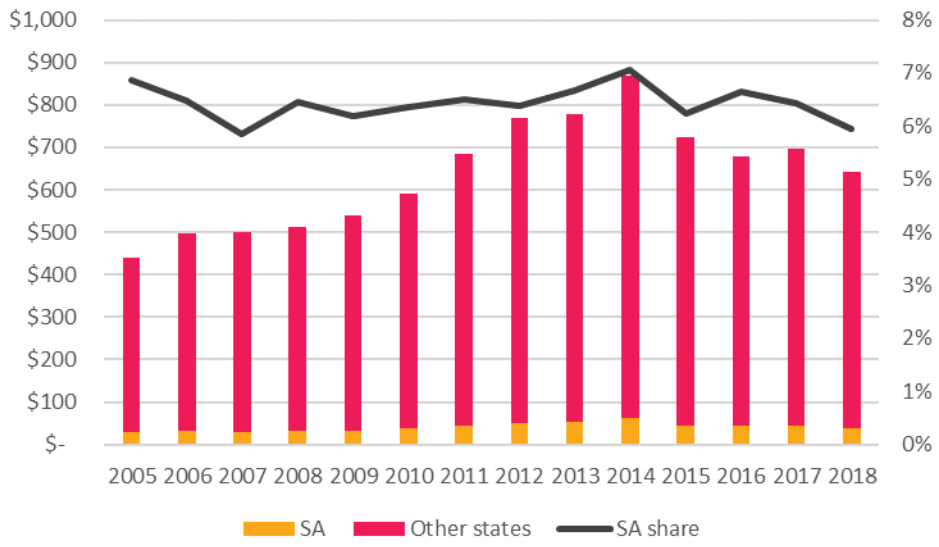
South Australia's share of Australia's total higher education expenditure on R&D (HERD) has declined from 7.3 per cent in 2006 to 6.8 per cent in 2018. Over this period, South Australian universities have experienced lower growth rates than the national average in all sources of funding except business and overseas, which combined, represent less than ten per cent of HERD funding.

3.3.1 Australian Government support for higher education R&D

ARC National Competitive Grants Program

South Australia's major universities received $45 million per year on average from the ARC over the ten years to 2018. This amounts to 6.5 per cent of all payments from the ARC over this period. South Australia's share of this income has fluctuated between 5.8 per cent (in 2007) and 7.1 per cent (in 2014). However, total ARC funding has been declining both nationally and in South Australia since 2014, as shown in Figure 3.8.

Figure 3.8: Category 1 funding – Australian Research Council, by location, 2005 to 2018, $m



Source: Department of Education, Skills and Employment HERDC

Other competitive grants

The Australian Government also provides significant funding through the National Health and Medical Research Council and the Medical Research Future Fund. As these relate primarily to health and medical research, the Commission has examined these as part of its separate inquiry into health and medical research in South Australia. Other sources of competitive grants include RDCs and any other grants listed on the Australian Competitive Grants Register (ACGR).

Research block grants

In 2020, the Australian Government provided $1.96 billion in research block grants, including $1.05 billion through the Research Training Program (RTP) and $910 million through the Research Support Program (RSP). The funding is awarded based on a formula that rewards universities for attracting research income. South Australian universities received 7.6 per cent of this funding in 2020 ($81.4 million through the RTP and $67.8 million through the RSP).

The RSP and RTP were introduced in 2017, replacing several programs. South Australian universities' funding under the RSP, RTP, and their predecessors, has increased at a slower rate than for Australia as a whole. As a result, South Australian universities' share of the RTP and its predecessors' funding fell from 8.2 per cent in 2001 to 7.8 per cent in 2020 and their share of RSP and its predecessors' funding has decreased from 10.2 per cent in 2001 to 7.5 per cent in 2020.

National Collaborative Research Infrastructure Strategy

Since 2004, the Australian Government has invested nearly $3.3 billion to create research infrastructure through the NCRIS[27]. This has attracted more than $1 billion in co-investment from state and territory governments, universities, research facilities and industry.

[27] Department of Education, Skills and Employment, National Collaborative Research Infrastructure Strategy (NCRIS, 2020), <https://www.education.gov.au/national-collaborative-research-infrastructure-strategy-ncris>

The NCRIS network currently supports national research capability through 23 active projects and comprises more than 200 institutions employing well over 1,900 technical experts, researchers and facility managers.

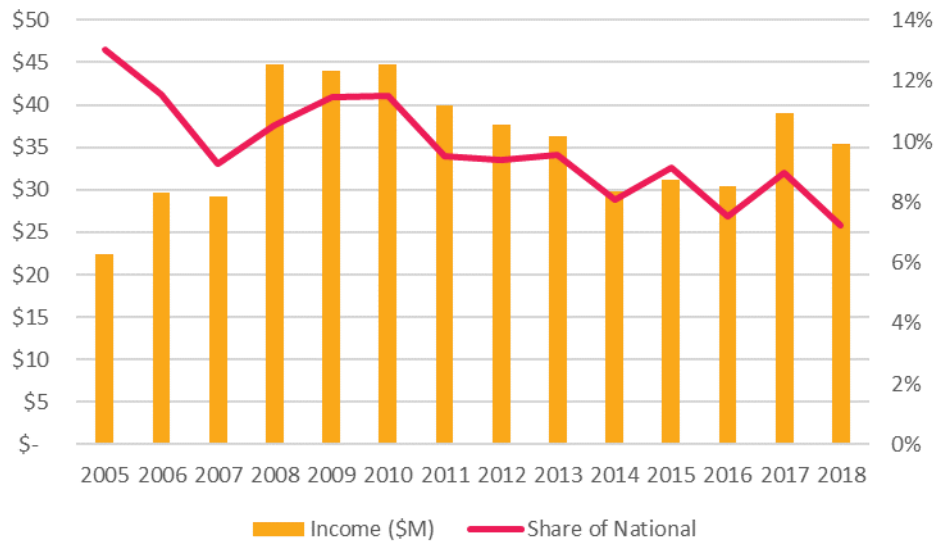
3.3.2 South Australian Government funding for higher education R&D

While state governments are a relatively minor funder of higher education R&D, the South Australian Government provides some support for higher education R&D through regular grant programs, ad hoc support and collaborative research projects with government agencies.

> *Examples of regular funding programs include the Premier's Research and Industry Fund (from which the University has received approximately $12M for three projects), and the Research, Commercialisation and Startup Fund (RCSF). In the latter case, three companies associated with the University (GPN Vaccines, Carina Biotech and FUSETEC) were awarded over $2M in April 2020. The RCSF also supports strategic research initiatives and a CRC Assistance Program funds, encouraging government agency involvement in bids. (University of Adelaide, DR9, p.12)*

South Australian universities' share of total income from state governments declined from 13 per cent in 2005 to 7.2 per cent in 2018, as shown in Figure 3.9. The Commission has not been able to estimate South Australian Government funding as this figure includes income from other state governments.

Figure 3.9: South Australian Universities' R&D income from state governments, $m, 2005-18



Source: Department of Education, Skills and Employment HERDC

The South Australian Government also supports South Australian universities to compete for nationally significant research infrastructure through co-investing in NCRIS programs. Since 2010-11, the South Australian Government, through the Department for Innovation and Skills, has allocated over $27 million to support NCRIS projects.

South Australia's higher education expenditure on R&D by field of research is presented in Table 3.11, with the share of expenditure by field presented for South Australia and Australia in Figure 3.10.

Table 3.11: Higher education expenditure on R&D, by field of research, SA, $m

Field of research	2008	2010	2012	2014	2016	2018	Trend
Agricultural and Veterinary Sciences	31	42	39	75	39	42	
Biological Sciences	35	42	55	56	75	95	
Built Environment and Design	5	9	13	8	19	8	
Chemical Sciences	24	29	37	39	34	28	
Commerce, Management, Tourism and Services	15	15	18	19	19	27	
Earth Sciences	17	14	26	21	18	20	
Economics	8	5	6	8	14	15	
Education	17	17	14	15	16	17	
Engineering	34	38	49	62	51	68	
Environmental Sciences	18	21	27	35	31	23	
History and Archaeology	5	2	2	2	5	11	
Information and Computing Sciences	15	12	20	19	49	38	
Language, Communication and Culture	9	8	9	9	10	8	
Law and Legal Studies	6	1	2	4	5	4	
Mathematical Sciences	7	11	9	11	8	10	
Medical and Health Sciences	185	207	237	266	240	314	
Philosophy and Religious Studies	2	1	1	1	2	1	
Physical Sciences	7	14	19	14	9	13	
Psychology and Cognitive Sciences	10	14	18	12	13	14	
Studies in Creative Arts and Writing	9	5	4	7	8	8	
Studies in Human Society	25	20	28	32	26	26	
Technology	22	18	9	11	18	36	
Total	**505**	**545**	**640**	**724**	**707**	**827**	

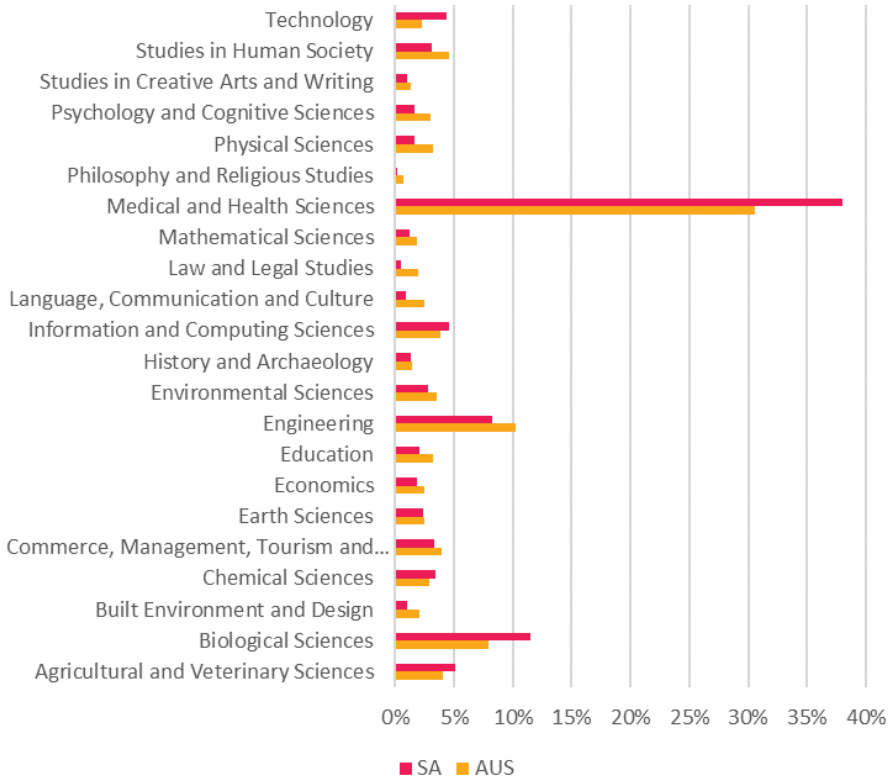
Source: ABS 8111.0

In 2018, 38 per cent of HERD in South Australia was in the medical and health sciences field. Biological sciences were the second largest field of research with 11.5 per cent of HERD, followed by engineering with 8.2 per cent.

Since 2008, the fastest growing fields by expenditure in South Australia have been biological sciences (10.6 per cent per year), information and computing sciences (9.6 per cent per year), history and archaeology (9.2 per cent per year, albeit from a low base) and engineering (7.0 per cent per year).

There are five fields of research whose expenditure on R&D in South Australia was lower in 2018 than in 2008. These include law and legal studies (31.7 per cent decrease), philosophy and religious studies (28.1 per cent decrease) and language, communication and culture (13.7 per cent decrease).

Figure 3.10: Higher education expenditure on R&D, by field of research, by location, SA and Australia, per cent of total, 2018



Source: ABS 8111.0

Compared to the national totals, South Australia's higher education research has a higher focus on medical and health sciences, biological sciences and technology.

This expenditure is also presented by socio-economic objective in Table 3.12.

Table 3.12: Higher education expenditure on R&D by socio-economic objective, South Australia, $m

Socio-economic objective	2008	2010	2012	2014	2016	2018	Trend
Defence	**10**	**17**	**14**	**7**	**9**	**11**	
Defence	10	17	14	7	9	11	
Economic Development	**132**	**144**	**181**	**213**	**198**	**209**	
Animal Production and Animal Primary Products	8	7	6	13	10	11	
Commercial Services and Tourism	5	5	5	5	4	6	
Construction	5	7	5	5	6	6	
Economic Framework	17	19	19	25	24	28	
Energy	7	11	21	17	27	23	
Information and Communication Services	16	15	19	19	20	27	
Manufacturing	20	19	35	40	30	32	
Mineral Resources (excl. Energy Resources)	13	13	16	39	12	18	
Plant Production and Plant Primary Products	33	39	49	46	62	50	
Transport	7	7	5	4	4	7	
Environment	**34**	**49**	**54**	**77**	**61**	**60**	

Socio-economic objective	2008	2010	2012	2014	2016	2018	Trend
Environment	34	49	54	77	61	60	
Expanding Knowledge	**62**	**48**	**65**	**94**	**94**	**186**	
Expanding Knowledge	62	48	65	94	94	186	
Society	**267**	**287**	**326**	**334**	**344**	**361**	
Cultural Understanding	26	16	17	18	16	18	
Education and Training	18	21	16	22	37	23	
Health	201	227	274	271	266	283	
Law, Politics and Community Services	22	23	19	23	25	37	

Source: ABS 8111.0

Table 3.13 presents the expenditure by type of activity for both the South Australian and Australian higher education sectors in 2018.

Table 3.13: Higher education expenditure on R&D by type of activity, by location, 2018

Type of Activity	South Australia		Australia	
	$m	%	$m	%
Applied research	357	43.1	5,884	48.4
Pure basic research	194	23.4	2,769	22.8
Strategic basic research	203	24.6	2,167	17.8
Experimental development	73	8.8	1,338	11.0
Total	**827**	**100.0**	**12,158**	**100.0**

Source: ABS 8111.0

Compared to the national average, South Australia's higher education R&D focusses less on applied research and experimental development. These types of research have been the fastest growing nationally, growing at an annual average of 8 percent and 10.8 per cent respectively. However, in South Australia these types of research have grown slightly more slowly than pure basic research and strategic basic research.

Current expenditure represented over 92 per cent of HERD in South Australia in 2018, with labour costs 40 per cent of total expenditure. While capital expenditure is volatile over time, it has been growing faster than current expenditure, with land, buildings and other structures the fastest growing category. However, capital expenditure in South Australia is a consistently smaller proportion of HERD than nationally (4.9 per cent of expenditure in 2018 compared to 6.9 per cent nationally).

3.4 Business

In 2017-18, South Australian businesses spent almost $800 million on R&D. However, compared to other states, only the ACT, Tasmania and the Northern Territory spend less, as shown in Table 3.14.

Table 3.14: Business expenditure on R&D, by location, $m, 2008-09 to 2017-18

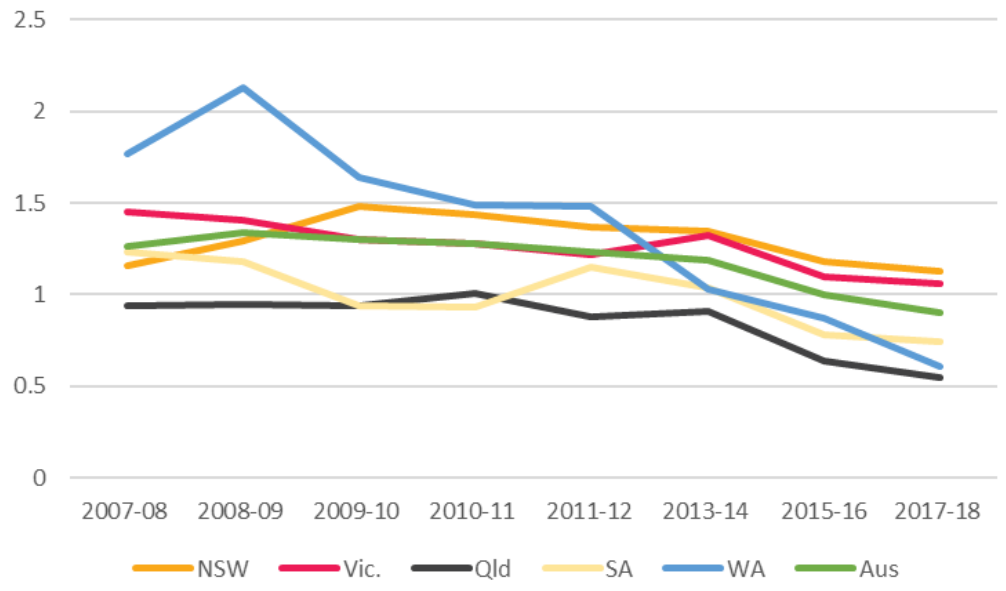
Location	2008-09	2009-10	2010-11	2011-12	2013-14	2015-16	2017-18	Trend
Australian Capital Territory	93.4	86.1	87.0	86.9	144.0	89.6	220.7	
New South Wales	5,362.1	6,078.5	6,345.6	6,382.7	6,651.6	6,420.9	6,823.0	
Northern Territory	101.5	122.6	149.4	137.7	218.9	72.2	31.4	
Queensland	2,496.7	2,364.1	2,679.0	2,498.7	2,699.8	1,955.6	1,912.3	
South Australia	937.7	791.8	842.6	1057.7	1003.8	774.3	798.0	

Location	2008-09	2009-10	2010-11	2011-12	2013-14	2015-16	2017-18	Trend
Tasmania	137.3	115.6	145.1	164.1	147.4	184.1	176.0	
Victoria	4,183.6	3,880.0	4,119.2	3,978.1	4,623.1	4,275.3	4,544.5	
Western Australia	3,638.0	2,968.9	3,265.3	3,584.9	2,732.2	2,082.2	1,592.3	
Overseas	340.9	352.0	373.7	430.7	628.6	805.0	1,339.4	
Total	17,291.2	16,759.6	18,006.9	18,321.3	18,849.4	16,659.3	17,437.6	

Source: ABS 8104.0

South Australia's business expenditure on R&D has declined since 2011-12, with the state's share of national expenditure decreasing from 5.8 per cent to 4.6 per cent.

Figure 3.11: Business expenditure on R&D as a percentage of GSP, by state



Source: ABS 8104.0

In 2017-18, South Australia had the third highest BERD to GSP ratio in Australia of 0.74, but below the Australian BERD to GDP ratio of 0.9, as shown in Figure 3.11. BERD as a percentage of GSP has been declining for most states over the past decade. South Australia has consistently had a lower BERD to GSP ratio than for Australia as a whole.

For Australia as a whole, more than half of BERD is attributed to businesses that employ 200 or more persons, with a further 26 per cent to businesses employing 20 to 199 persons, as shown in Table 3.15.

Table 3.15: Business expenditure on R&D, by employment size, Australia, 2016-17, $m

Industry	Number of Employees				Total expenditure on R&D
	0-4	5-19	20-199	200+	
Agriculture, Forestry and Fishing	29.7	34.8	161.3	87.8	313.6
Mining	129.0	179.4	168.5	572.9	1,049.8
Manufacturing	132.2	378.7	1,039.3	3,049.2	4,599.5
Electricity, Gas, Water and Waste Services	16.2	82.1	19.5	235.2	353.0
Construction	30.7	56.4	96.8	165.2	349.2
Wholesale Trade	37.6	177.8	375.9	339.3	930.5
Retail Trade	28.8	59.0	94.1	60.3	242.2

Industry	Number of Employees				Total expenditure on R&D
	0-4	5-19	20-199	200+	
Accommodation and Food Services	1.0	5.3	12.0	19.5	37.8
Transport, Postal and Warehousing	2.5	13.6	31.1	73.3	120.4
Information Media and Telecommunications	47.5	119.8	131.9	310.8	610.1
Financial and Insurance Services	24.8	116.9	288.4	2,416.8	2,847.0
Rental, Hiring and Real Estate Services	30.9	50.8	75.1	37.0	193.8
Professional, Scientific and Technical Services	753.5	1,331.0	1,801.3	1,227.4	5,113.1
Administrative and Support Services	8.8	27.6	51.2	79.2	166.8
Public Administration and Safety	3.1	-	13.5	-	21.9
Education and Training	8.0	-	21.7	-	50.6
Health Care and Social Assistance	33.1	24.3	48.2	35.3	140.8
Arts and Recreation Services	5.4	7.2	46.2	63.9	122.8
Other Services	26.8	46.5	61.1	40.3	174.7
All Industries	1,349.6	2,730.6	4,537.1	8,820.3	17,437.6
Per cent of Total	***7.7***	***15.7***	***26.0***	***50.6***	***100.0***

Source: ABS 8104.0

This is true across the four industries which had an expenditure exceeding $1 billion in 2016-17[28], with the exception of professional, scientific and technical services. In this sector, 76 per cent of expenditure was conducted by firms with less than 200 employees and over 40 per cent by firms with less than 20 employees.

Overwhelmingly, business fund its own R&D (95 per cent) with only minor contributions from other funding sources. They include Australian Government (2.1 per cent), with state and local governments funding only 0.3 per cent of business expenditure on R&D.

Government support for business R&D in Australia is heavily targeted towards indirect incentives, such as the R&D tax offset, rather than direct support, compared to many other countries.

Approximately 60 per cent of South Australia's business expenditure on R&D was in the two industries of professional, scientific and technical services (34.5 per cent) and manufacturing (24.7 per cent) in 2017-18. Despite these two industries representing the largest proportion of South Australia's business expenditure on R&D, South Australian businesses represent less than five per cent of the national total across these two industries.

The types of R&D activities that business conduct in Australia are presented in Table 3.16.

[28] These four sectors are: professional, scientific and technical services; manufacturing; financial and insurance services; and mining. Together they account for 78 per cent of Australia's business expenditure on R&D.

Table 3.16: Business expenditure on R&D, by type of activity, Australia, $m

	2008-09	2009-10	2010-11	2011-12	2013-14	2015-16	2017-18
Applied research	5,935	5,633	5,925	5,822	6,134	4,796	5,567
Experimental development	10,402	10,211	11,054	11,403	11,521	10,855	10,410
Pure basic research	87	85	98	120	173	125	143
Strategic basic research	866	831	929	976	1,021	883	1,318

Source: ABS 8104.0

Businesses primarily undertake experimental development (59.7 per cent) and applied research (31.9 per cent). Despite representing less than ten per cent of business expenditure, pure basic research and strategic basic research have both been growing at over 6 per cent per year.

By socio-economic objective, business expenditure on R&D in Australia is primarily targeted at manufacturing (28.2 per cent), information and communication services (19.4 per cent), commercial services and tourism (17.2 per cent) and health (9.1 per cent).

Over the past ten years, there has been a significant decline in business expenditure on R&D for mineral resources (down $1,154 million or 52.7 per cent) and energy (down $1,137 million or 54.2 per cent). There has been significant growth in expenditure in health ($1,190 million or 295.8 per cent), information and communication services ($1,455 million or 75.5 per cent) and commercial services and tourism ($1,287 million or 75.1 per cent).

3.5 Conclusion

As measured by expenditure, the level of R&D activity in South Australia is high relative to other states in Australia. However, the composition of R&D in South Australia differs significantly from the total for Australia as a whole. South Australia has higher levels of government and higher education expenditure on R&D, but lower levels of business expenditure.

Table 3.17: Expenditure on R&D as a per cent of GSP, by sector, by state

Sector	Year	NSW	Vic.	Qld	SA	WA	Tas.	NT	ACT
Australian Government	2018-19	0.05	0.12	0.07	**0.31**	0.05	0.44	0.13	0.79
State government	2018-19	0.06	0.06	0.10	**0.10**	0.04	0.01	0.09	0.02
HERD	2018	0.60	0.75	0.54	**0.75**	0.39	0.62	0.29	1.77
BERD	2017-18	1.13	1.06	0.55	**0.74**	0.61	0.57	0.12	0.55
Total*	Various	1.84	1.99	1.26	**1.90**	1.09	1.64	0.63	3.13

**Total is indicative only and based on the most recent year available for each sector. Numbers are not directly comparable across sectors due to differences in the collection period.*

Source: ABS 8109.0, ABS 8111.0, ABS 8104.0

Across Australia, businesses conduct more than half of all R&D and over 95 per cent of business R&D is self-funded. Businesses that employ over 200 staff account for over half of all business R&D expenditure in Australia. Approximately 60 per cent of South Australia's business expenditure on R&D is in the two industries of professional, scientific and technical services and manufacturing.

The higher education sector has been the fastest growing sector of R&D expenditure, but South Australia's higher education R&D sector has not been growing as quickly as Australia's. In addition, a major factor in the growth of higher education R&D has been the increase in non-competitive R&D funding, including general university funding and other

Commonwealth funding. These funding sources are under significant risk as a result of the current COVID-19 pandemic and its negative impact on international student revenues.

While government expenditure on R&D is much lower than higher education and business expenditure, relative to the size of the economy, South Australia has higher levels of government expenditure (state and commonwealth) than the national average.

One of the South Australian Government's main R&D expenditures is on agriculture, with SARDI representing over half of South Australian Government expenditure, although up to 85 per cent of this expenditure is funded from other sources, including the Australian Government and industry. Other significant areas of expenditure are in health and medical research (which the Commission is investigating as part of a separate inquiry) and general support for business and university R&D.

In addition, once the base funding to SARDI, the annual grant to SAHMRI and the DIS grants are excluded, it is worth noting that the balance of funding is spread across a number of agencies in relatively small amounts (see table 3.6) that vary substantially from year to year and almost none seems to be allocated in a competitive manner.

The Commission notes that the SA government own sourced expenditure on research seems relatively low after all funding from external sources is removed (see table 3.7); however, as the Commission was not able to identify other state level R&D budgets, it cannot category conclude that the level of spend is inadequate. That said, if the state wants a more active R&D sector, it will need to consider not only the effectiveness of its own spend, but whether additional expenditure in selected areas is warranted. Both these issues are discussed in more detail in Chapter 7.

4. Measuring the performance of R&D in South Australia

4.1 Introduction

This chapter examines the relative performance of South Australia compared to other jurisdictions, focusing on those aspects of R&D that are considered critical for economic growth.

In summary, the Commission has found that South Australian businesses' propensity to invest in R&D is broadly in line with other states, having regard to the industry mix in the state's economy, with businesses in the state spending about $800 million in 2017-18. That said, South Australia's business expenditure on R&D has declined since 2011-12, with the state's share of national expenditure decreasing from 5.8 per cent to 4.6 per cent.

Measures of collaboration between the basic research sector and industry, while in line with other states, are lower than most OECD countries. In addition, the share of venture capital funds which comes to South Australia is lower than in other states.

In the higher education sector, several research fields in South Australia perform at global levels in terms of quality; however, scale is often small, which leads to a concern about the sustainability of the high level of performance. The funding share of competitive grants for South Australia has been less than its population share between 2006 and 2018.

4.2. R&D performance in South Australia

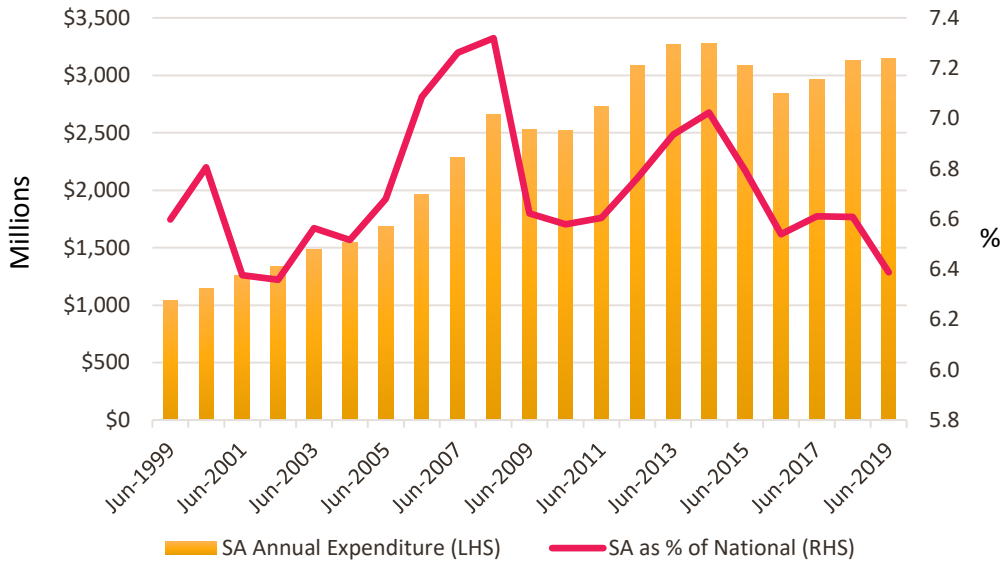
4.2.1. National accounting perspective

The 2008 International System of National Accounts treats the acquisition of R&D services by a firm from the buyer's perspective, in most cases as an acquisition of an R&D asset[29]. Thus, domestic sales of R&D output are no longer offset by intermediate consumption, on the part of the purchaser, in the calculation of GDP, causing output, as well as the capital stock, to increase[30,31].

Figure 4.1 shows that IP capital formation in South Australia rose steadily in the period 1999 to 2013 and declined thereafter, mirroring trends in Queensland and Western Australia. South Australia's share of national IP capital formation has declined slightly over the 20 years to 2019 (from 6.6 per cent to 6.4 per cent).

[29] EC, IMF, OECD, UN and the World Bank, System of National Accounts (United Nations, New York, 2009). In the 2008 edition of the International System of National Accounts (SNA), the treatment of expenditure on R&D changed from an expense to a capital investment leading to a capital stock of knowledge created as a result of the R&D. R&D expenditure aggregates are different from, though related to, R&D capital formation.
[30] Daniel Ker and Fernando Galindo-Rueda, Frascati Manual R&D and the System of National Accounts, OECD Science, Technology and Industry Working Papers 2017/06 (OECD Publishing, Paris, 2017) p. 7.
[31] Intellectual property capital formation consists of expenditure on research and development, mineral and petroleum exploration, computer software and artistic originals. The components of intellectual property capital formation are published at national level but not at state level. From the 2008-09 edition, the ABS national accounts reflected the changes at international level. The Commission has drawn on the ABS intellectual property capital formation data in its analysis which has been rebased by the ABS to 2000-01.

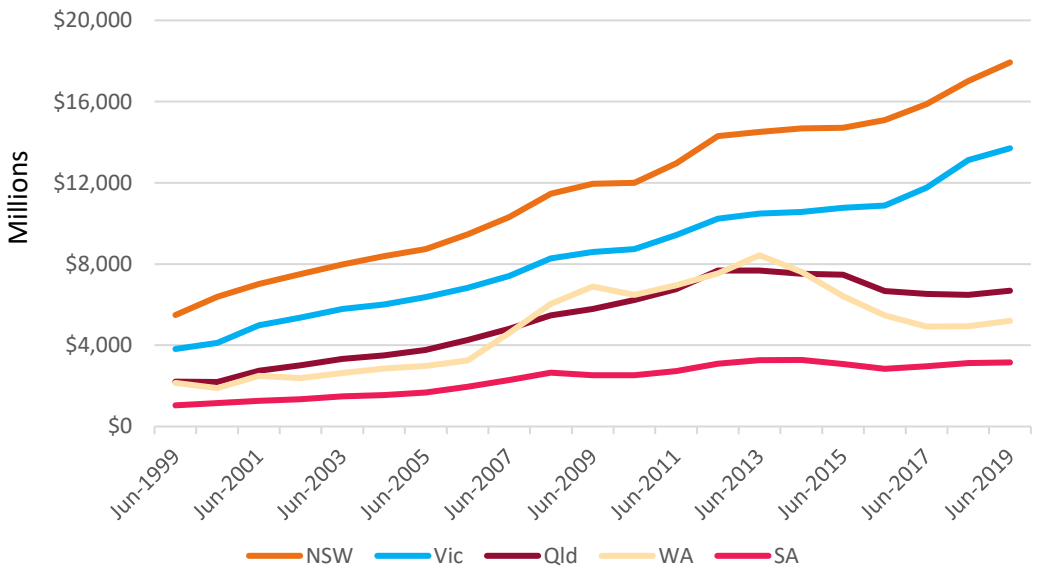
Figure 4.1: Intellectual property capital formation ($m current prices), South Australia, 1999-2019



Sources: ABS Catalogue No. 5220.0, Australian National Accounts: State Accounts, 2018-19, Table 24, South Australia capital stock by type of asset and ABS Catalogue No. 5204.0, Australian System of National Accounts, 2018-19, Table 56 capital stock by type of asset

South Australia's performance is mixed compared with other jurisdictions. The growth in IP capital formation has been pronounced in Victoria and New South Wales, with Queensland's total expenditure tripling over the period (in line with South Australia, albeit with SA coming from a lower base), as shown in Figure 4.2. Western Australia's IP capital formation has shown relatively lower absolute growth.

Figure 4.2: Intellectual property capital formation ($m current prices), selected jurisdictions



Source: ABS Catalogue No. 5220.0, Australian National Accounts: State Accounts, 2018-19, Selected tables on capital stock by type of asset, institutional sector and industry

4.2.2. Business expenditure

The Commission investigated whether SA businesses, compared to the national average, are more or less likely to undertake R&D, and the spending and industry profile of R&D activity using individual business level data. The ABS analysed for the Commission the aggregate R&D tax expenditures and number of eligible business from the 2018-19 Business Longitudinal Analysis Data Environment (BLADE)[1] Core products. The BLADE Core uses the Australian Bureau of Statistics Business Register (ABSBR) as the frame and source of demographic data items. The aggregate R&D data is sourced from the Australian Taxation Office (ATO) Business Income Taxation (BIT) reporting[32].

Table 4.1 presents the aggregate eligible expenditure and aggregate tax incentive offsets claimed by eligible companies by industry for South Australia and Australia. Where confidentiality concerns occurred, numbers at industry level were not provided to the Commission.

The data shows eligible expenditure on R&D by South Australian companies over the period 2011-12 to 2017-18 accounted for 3.2 per cent of the national total. R&D taxation incentive offsets claimed by South Australian companies were 4.7 per cent of the national total, with both proportions being somewhat less than the state's population share. (The numbers in individual years are volatile and greatly affected by the previous scheme preventing a more detailed analysis). These results are not unexpected given the state's lower than Australia-wide performance on BERD spending (South Australia's industry structure and the dominance of small businesses explain a significant part of that result).

The greatest contributors to R&D taxation incentive offsets at an industry level in South Australia are the professional, scientific and technical services and manufacturing sectors comprising 40.0 per cent and 23.7 per cent respectively of the state total. This mirrors the result at a national level where the proportions are 42.8 and 16.0 per cent respectively.

Table 4.1: Aggregate eligible expenditure and R&D taxation concession offsets, South Australia and Australia, 2011-12 to 2017-18, ($m)

Industry division	SA expenditure	Australia expenditure	SA – Tax incentive offsets	Australia – Tax incentive offsets
Agriculture, forestry and fishing	152.5	1,660.8	40.9	402.3
Mining	71.9	10,873.5	64.6	1,365.5
Manufacturing	1,261.9	23,609.6	174.0	2,488.9
Electricity, gas, water and waste services	N/A	1,678.4	N/A	209.3

[32] The results of these studies are based, in part, on Australian Business Register data supplied by the Registrar to the ABS under A New Tax System (Australian Business Number) Act 1999 and tax data supplied by the ATO to the ABS under the Taxation Administration Act 1953. These require that such data is only used for the purpose of carrying out functions of the ABS. No individual information collected under the Census and Statistics Act 1905 is provided back to the Registrar or ATO for administrative or regulatory purposes. Any discussion of data limitations or weaknesses is in the context of using the data for statistical purposes and is not related to the ability of the data to support the Australian Business Register or ATO's core operational requirements. Legislative requirements to ensure privacy and secrecy of this data have been followed. Only those authorised under the Australian Bureau of Statistics Act 1975 have been allowed to view data about any firm in conducting these analyses. In accordance with the Census and Statistics Act 1905, results have been made confidential to ensure that they are not likely to enable identification of a person or organisation. The customised data request provides R&D eligible expenditure and R&D taxation incentive data for SA and Australia where R&D eligible businesses (companies only) are counted based on the ABS Units Model.

Industry division	SA expenditure	Australia expenditure	SA – Tax incentive offsets	Australia – Tax incentive offsets
Construction	88.6	4,718.5	29.9	452.7
Wholesale trade	171.8	7,279.8	34.2	785.2
Retail trade	42.4	1,547.0	20.1	392.4
Accommodation and food services	N/A	193.0	N/A	53.8
Transport, postal and warehousing	13.8	1,017.0	N/A	137.2
Information media and telecommunications	52.3	2,470.6	17.8	565.8
Financial and insurance services	96.4	8,885.3	28.2	713.1
Rental, hiring and real estate services	57.3	1,337.5	21.1	405.0
Professional, scientific and technical services	905.1	22,077.6	293.1	6,638.0
Administrative and support services	27.1	1,425.3	1.9	269.1
Public administration and safety (private)	N/A	275.6	N/A	55.5
Education and training (private)	N/A	352.4	N/A	121.7
Health care and social assistance (private)	8.4	686.1	2.1	196.0
Arts and recreation services	N/A	452.1	N/A	73.0
Other services	9.5	647.5	5.7	193.4
Total	**2,958.9**	**91,187.6**	**733.6**	**15,517.8**

Source: Australian Bureau of Statistics, Business Longitudinal Analysis Data Environment Core products: Customised table provided to the Commission on request.

The BLADE data set also provided some insight into the percentage of companies with R&D expenditures by jurisdiction. The proportion of South Australian companies with R&D expenditures (1.6 per cent) is higher than the national average (1.5 per cent) and all other states apart from Victoria (1.6 per cent) and Western Australia (1.9 per cent), as shown in Table 4.2.

Given that South Australia is over-represented in businesses of small size, the number of businesses undertaking R&D is higher than the Australian average and total expenditure is much lower than population share, the important conclusion is that small businesses in South Australia have a higher propensity to invest in R&D activity. The lack of medium and large-sized businesses in South Australia results in lower overall spend at firm, industry and state level. The implications are that the scale of R&D operations is a key factor in driving investment in assets, both knowledge and physical, and that limited transition of startups and small businesses to larger businesses puts a ceiling on development in the state.

Table 4.2: Percentage of companies with R&D expenditures by jurisdiction

State	No R&D (%)	With R&D (%)	Total (%)
NSW	98.7	1.3	100
VIC	98.4	1.6	100
QLD	98.6	1.4	100
SA	**98.4**	**1.6**	**100**
WA	98.1	1.9	100

State	No R&D (%)	With R&D (%)	Total (%)
TAS	98.7	1.3	100
NT	99.6	0.4	100
ACT	99.0	1.0	100
Australia	**98.5**	**1.5**	**100**

Source: Australian Bureau of Statistics, Business Longitudinal Analysis Data Environment Core products: Customised table provided to the Commission on request.

The ABS undertook a regression analysis on behalf of the Commission to determine the propensity of firms in South Australia to undertake R&D. The analysis made use of the 2017-18 (BLADE)[1] dataset to examine whether spending on R&D is associated with business demographic characteristics such as industry division, employment (or business) size, age of the firm, main state of location, and selected financial variables such as turnover and depreciation[33].

The results showed significantly different probabilities across industries, business sizes and states and territories (The detailed results are provided in Appendix 4 of the draft report). Companies in SA are generally more likely to spend on R&D compared to those in other states except in WA, after controlling for other influencing factors. Examining the estimated odds ratios for business location, the likelihood of a South Australian business spending on R&D is higher than those of businesses from all states and territories except WA. WA firms are 1.1 times more likely to spend on R&D than SA firms. Among all industries, the likelihood of spending on R&D is highest for the mining industry.

The results also indicate that large companies are significantly more likely to spend on R&D across Australia. As the company employment size increases the odds for the likelihood of the firm spending on R&D increases. The propensity for companies to spend on R&D increases as their total income increases, and younger firms are more likely to spend on R&D compared to older firms, controlling for other factors. The implications for South Australia of larger businesses being more likely to spend on R&D are important given the relatively lower number of medium and large-size businesses.

Industry structure and composition

In South Australia 98 per cent of all businesses are small, having fewer than 20 employees. Over 60 per cent of businesses do not employ any staff, and only a small percentage have a turnover greater than $5 million per annum. Crucially, the percentage of large businesses in the state is roughly half the national average. Consequently, local businesses have neither the human or financial resources to pursue R&D. In the case of medium and larger businesses, many are headquartered in other jurisdictions which results in R&D activity being conducted in those other locations.

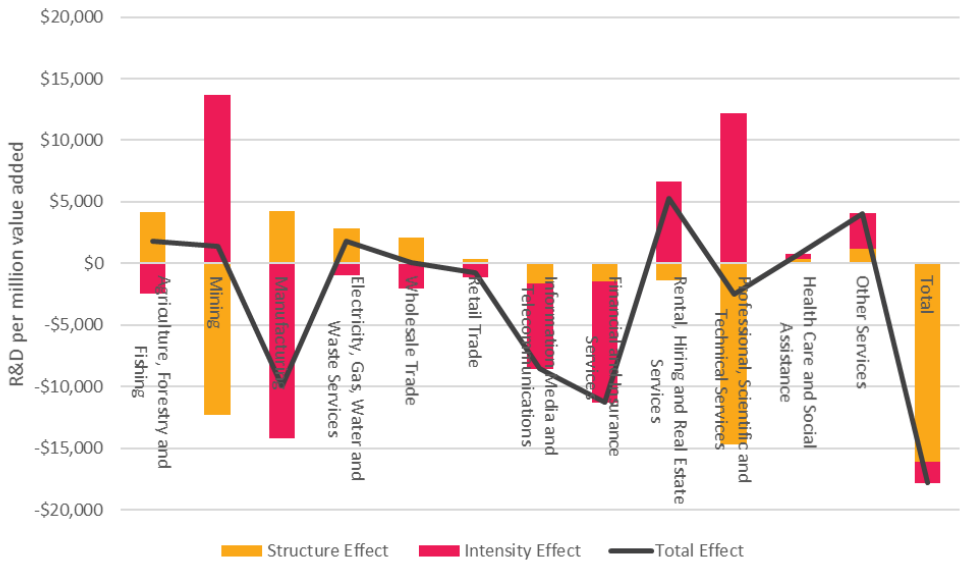
One way to examine the effect of industry structure on business expenditure on R&D is to look at differences in R&D intensity within sectors, either through time or across jurisdictions. Differences in economy-wide R&D intensity can be a result of differences in the intensity of R&D within industry sectors or as a result of changes in industry structure either towards or against more R&D intensive industries. R&D intensity is defined in this context as the ratio of business R&D expenditure to gross value added (GVA). Several different methodologies have been used to decompose changes of R&D intensity into an effect of industry structure

[33] The dependent variable is the log of the odds of the business reporting a positive value of R&D expenditures.

(structure effect) and industry intensity (intensity effect)[34]. For its analysis, the Commission has applied the Logarithmic Mean Divisia Index method of Sato[35] and applied business R&D expenditure by the OECD[36].

In comparing South Australia's R&D intensity to that of Australia in 2017-18, South Australia had approximately $17,800 less BERD per $1 million of GVA. The Commission estimates that, of this difference, over $16,100 can be attributed to differences in industry structure, with a further $1,700 a result of lower R&D intensity within industry sectors. The contribution of each effect by industry sector is shown in Figure 4.3.

Figure 4.3: Sectoral contribution to differences between South Australia's and Australia's Business R&D intensity, 2017-18



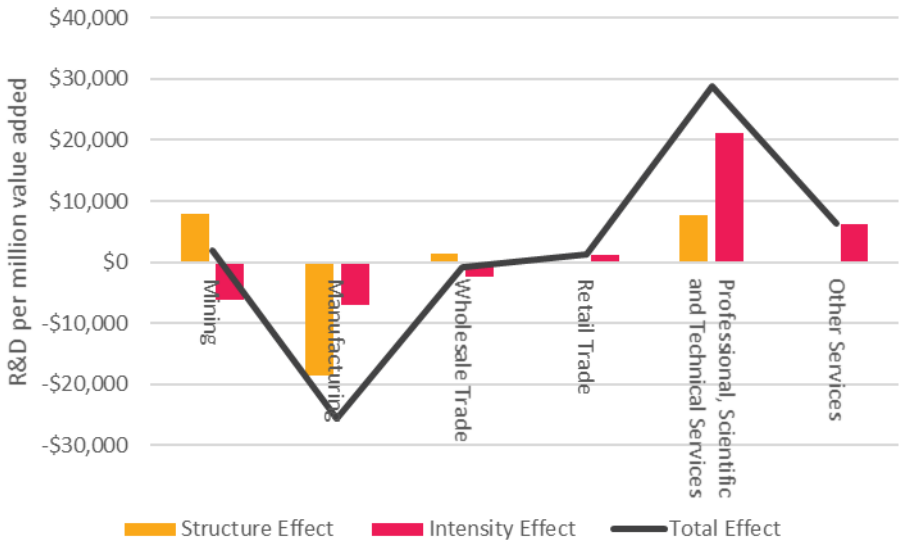
Source: ABS 5204.0, ABS 5220.0, ABS 8104.0 and SAPC calculations

South Australia had higher R&D intensity than for Australia in the sectors of: agriculture, forestry and fishing; mining; electricity, gas water and waste services; rental, hiring and real estate services; and other services. South Australia's higher levels of R&D expenditure in agriculture, forestry and fishing are mainly as a result of the sector being larger in South Australia, despite these firms having a lower R&D intensity compared to the national average for the sector. The opposite is true for the mining sector, as South Australian firms were more R&D intensive despite representing a smaller proportion of the overall economy.

This methodology also allows, in principle, the examination of changes in business R&D expenditure over time. Data limitations preclude this for South Australia because the ABS has not published business R&D expenditure for all sectors in all time periods for confidentiality reasons. However, it is possible to examine the effect in some of the major industry sectors, shown in Figure 4.4.

[34] For a discussion of the types of methodologies available see: P Moncada-Paternò-Castello, Corporate R&D intensity decomposition: Theoretical, empirical and policy issues, (2016), European Commission, JRC Technical Reports.
[35] K Sato, 'The Ideal Log-Change Index Number' (1976) 58, Review of Economics and Statistics, 223-228.
[36] V Koutsogeorgopoulou and T Park, Boosting R&D outcomes in Australia (2017), OECD Economics Department Working Papers, No. 1391. p.10.

Figure 4.4: Sectoral contribution to changes in business R&D intensity, South Australia, 2006-07 to 2017-18



Source: ABS 5220.0, ABS 8104.0 and SAPC calculations.

Professional, scientific and technical services represent the largest share of business R&D expenditure in South Australia (34.5 per cent in 2017-18), and as shown in Figure 4.3 South Australia has a significantly higher R&D intensity in this sector, despite it representing a much smaller proportion of the South Australian economy.

Since 2006-07, the professional, scientific and technical services sector contributed an increase in business R&D intensity of approximately $28,800 per $1 million GVA. Approximately $7,700 is a result of growth in this sector's share of the South Australian economy, with a further $21,100 a result of increased R&D intensity of firms within this sector.

Manufacturing is the second largest contributor to business R&D in South Australia (24.7 per cent in 2017-18). While manufacturing represents a larger share of the South Australian economy, South Australian manufacturing firms are significantly less R&D intensive than for Australia as a whole.

Since 2006-07, the manufacturing sector has witnessed a reduction of $25,600 in business R&D expenditure per $1 million in GVA. This is mostly explained by the decline of the manufacturing sector in South Australia ($18,500 per $1 million GVA); however, South Australian manufacturers have also become less R&D intensive.

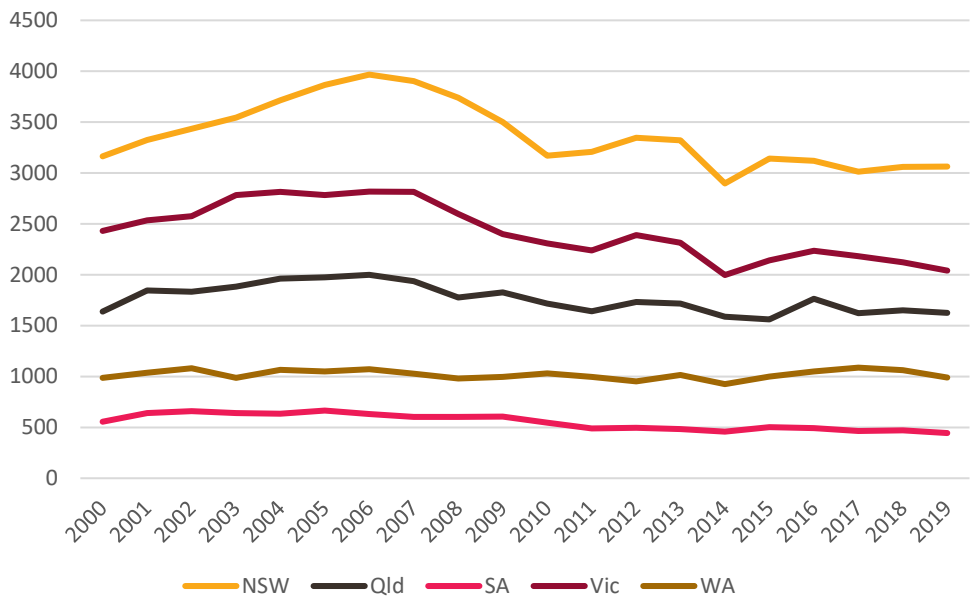
4.2.3. Patents

A patent represents a minimal amount of invention which has passed both the scrutiny of patent office assessors and the test of the organisation of the investment of effort and resources into the development of a product or process. This indicates an expectation of the patent's utility and marketability. The Commission notes that not all research is patented, the inventions or processes that are patented vary greatly in quality and the attribution of knowledge that goes into patent generation is difficult to track and quantify[37].

[37] Zvi Griliches, Patent Statistics as Economic Indicators: A Survey Part I, National Bureau of Economic Research Working Paper Series No. 3391, (March 1990).

A patent document contains information on the type of industry and technology, cites previous patents and associated scientific publications, and describes the invention. In Figure 4.5, the Commission uses state-based information of total standard patent applications as a proxy for relative outputs of inventive activity. It shows a decline in patent applications in all selected jurisdictions across Australia between 2000 and 2019. South Australia's level of patent applications has been relatively flat though also declining over the period. South Australia's share of national patents has remained relatively constant over the 20-year period declining marginally from 6.0 per cent in 2000 to 5.8 per cent in 2019.

Figure 4.5: Annual patent applications (no.) for selected jurisdictions, 2000-19



Source: IP Australia (Data includes standard patent applications for individuals as well as organisations and therefore differs from published data.)

Data for South Australian IP outputs against national outputs for trademarks and designs are similar to that for patents, with South Australia generating 6.0 per cent and 5.9 per cent of national outputs respectively over the period 2000-19.

Patent data can help to identify collaborations by indicating the proportion of joint patent applications involving more than one organisation as a proportion of total patent applications. Applying for a patent demonstrates that all parties have worked together to the point of application and it indicates that the outcomes have delivered some tangible results.

A cross-country study of the contributions of research institutions to innovation found that patent applications jointly filed by public research institutions and industry made up 29 per cent of all patents applications of universities and public research institutions in 2014, up from 17 per cent in 1992, suggesting an increase in co-creation between research institutions and industry[38].

South Australian researchers and businesses are just as likely as businesses at the national level to collaborate on a patent application (see Table 4.3). South Australian organisations collaborated on 17.1 per cent of all standard patent applications between 2000 and 2019, in

[38] Caroline Paunov, Martin Borowiecki and Nevine El-Mallakh, Cross-country evidence on the contributions of research institutions to innovation, OECD Science, Technology and Industry Policy Papers September 2019, No. 77 (OECD Publishing, 2019).

line with the national average of 17.3 per cent. Note also that jurisdictions with smaller populations are well above the Australian average, suggesting that greater ease of establishing networks, geographic proximity or small numbers of research organisations may have an influence on the level of collaboration in these jurisdictions.

Table 4.3: Proportion of standard patent applications with joint applicants (%), 2000-19

Jurisdiction	Proportion of patent filing applications collaborating with another party (%)[39]
ACT	21.5
NSW	16.6
NT	20.3
QLD	18.6
SA	**17.1**
TAS	22.1
VIC	16.8
WA	17.6
Australia	17.3

Source: IP Australia, Intellectual Property Government Open Data (IPGOD) unpublished data, on request from the SAPC

4.2.4. Influence of publicly funded research

Several econometric studies have investigated the impacts of universities on productivity and growth. A cross-country study using data on 15,000 universities in approximately 1,500 regions across 78 countries for the years 1950 to 2010 shows that an increase in the number of universities is positively associated with GDP per capita growth[40].

The higher education sector measures both inputs and outputs involved in its R&D efforts. The universities set targets for grants applications, grant types and success rates from the various funding schemes operated by the Australian Government. These targets relate to the amount of external research income, defined as income counted in the HERDC-reported research income. Funding outcomes are discussed in Chapter 3.

The university sector uses a range of metrics to review research performance. Principal among these are:

- the number of Higher Degree by Research student completions (this indicator is discussed in section 6.1);
- the number and quality of research outputs (both traditional and non-traditional research outputs), with emphasis on ERA-eligible publications;
- performance in the national ERA assessment exercise;
- performance in the national Engagement and Impact (EI) assessment exercise;
- protection and commercialisation of IP as measured by numbers of patents and numbers of licenses granted, as well as income from these activities; and
- research income (discussed in aggregate in Chapter 3).

[39] Note that as joint applications can include international applicants.
[40] A Valero and J Van Reenen, 'The Economic Impact of Universities: Evidence from Across the Globe'(2019) 68 Economics of Education Review, 53-67.

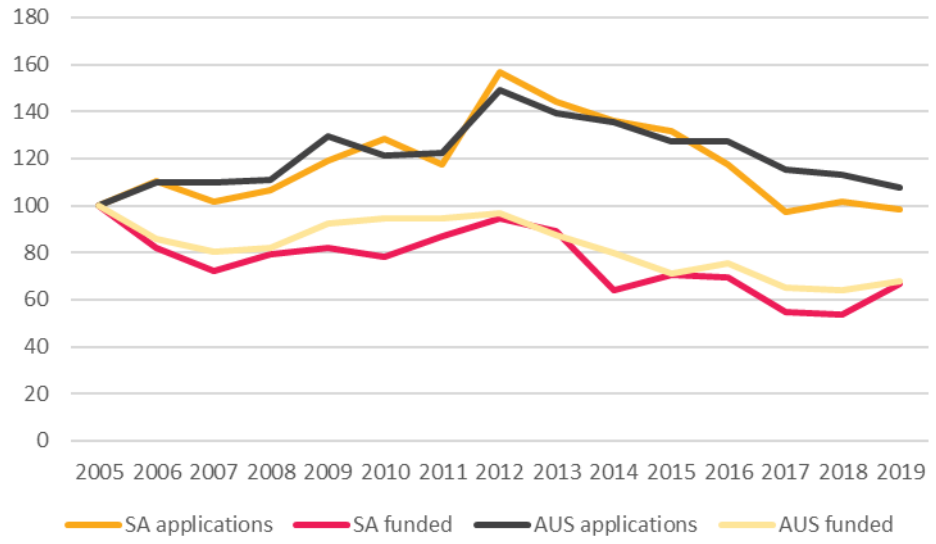
Other metrics, such as the number of publications with external/international authors, are also used for measurement purposes.

Grant funding and success rates

As discussed in Chapter 3, the major sources of competitive grant funding for South Australian universities are the ARC, the NHMRC and the MRFF. The performance of South Australian universities in obtaining funding from these latter sources is discussed in detail in the Commission's Inquiry into Health and Medical Research. Therefore, the focus of this section is on ARC funding.

The total amount of ARC funding provided to universities and the number of applications funded have declined since 2014 (see figure 4.6), both in South Australia and nationally. While South Australia's share of national funding fluctuates, it has remained relatively constant at between 5.8 and 7.1 per cent over the past decade. South Australia's share of ARC funding is defined by three distinct elements: the number of applications, the size of grants and the success rate in obtaining grants.

Figure 4.6: Number of applications for ARC funding and number of grants awarded, SA and AUS (Index 2005=100), 2005 to 2019

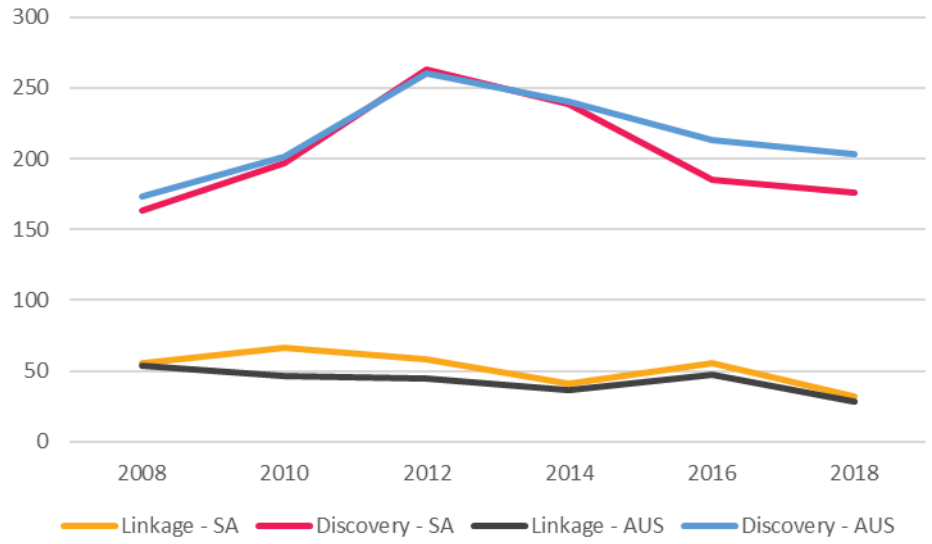


Source: ARC data, SAPC calculations[41]

The number of applications for ARC funding per thousand academic staff is presented in Figure 4.7.

[41] As ARC funding is typically committed for multiple years, for the purposes of the Commission's analysis the total amount of the ARC grant has been allocated to the year in which the project commenced.

Figure 4.7: Number of applications for ARC funding per thousand academic staff, counted as person years of effort (PYE), SA and AUS, all programs, 2008 to 2018

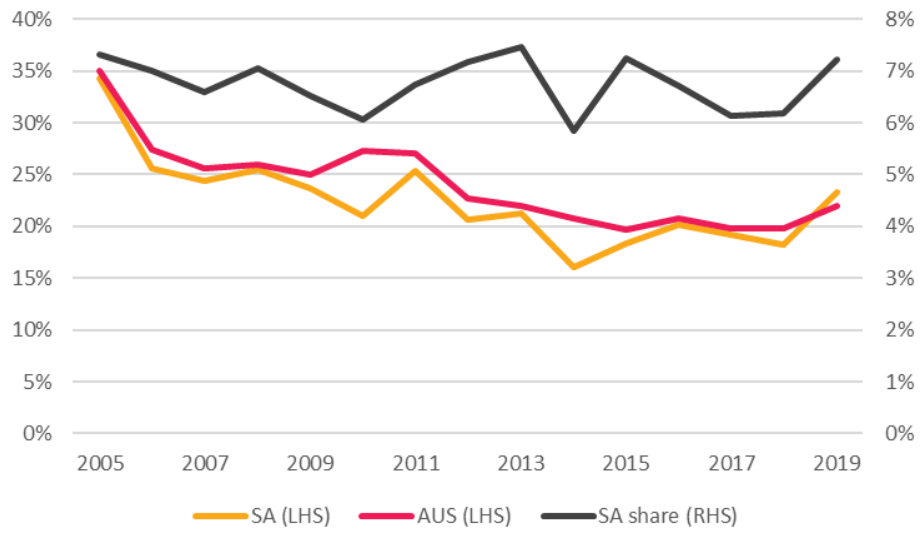


Source: ARC data, ABS 8111.0, SAPC calculations

Compared with the national average, South Australian universities had a lower rate of applications per staff member for ARC funding. While application rates vary across years, generally South Australia had lower application rates for Discovery Schemes while applications for Linkage Schemes tended to be at a rate higher than the national average.

The number of grants awarded by the ARC per year has declined by 32 per cent nationally since 2005, as shown in Figure 4.8. As a result, the proportion of applications which are successful in obtaining funding has also declined from 35 per cent in 2005 to 22 per cent in 2019.

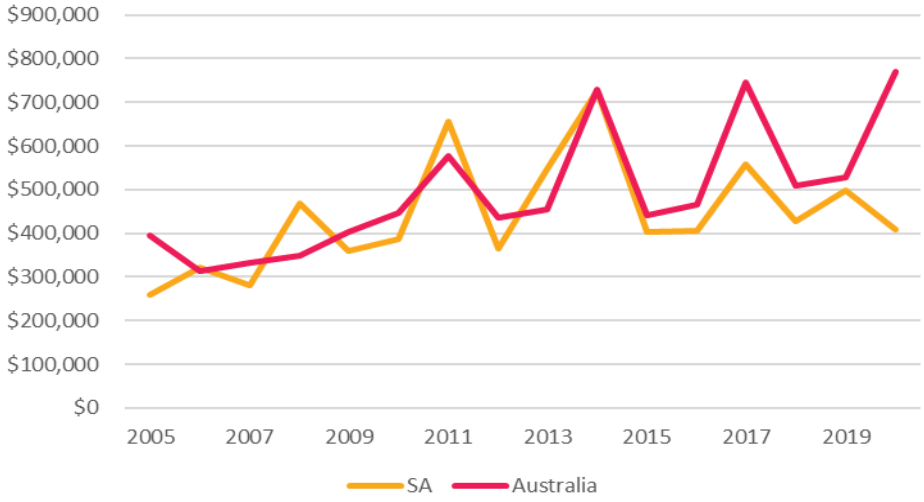
Figure 4.8: ARC proportion of successful applications, SA and AUS, annually, 2005 to 2019



Source: ARC data, SAPC calculations

The average grant size across all programs is presented in Figure 4.9.

Figure 4.9: Average ARC grant size, all programs, SA and AUS, annually, 2005 to 2019



Source: ARC data, SAPC calculations. Average grant size is defined as total funding allocated in a given year divided by the total number of grants allocated.

Since 2014, the average grant size for South Australian universities has been lower than the Australian average. This is largely a result of South Australia not winning any new funding through the ARC Centres of Excellence program since 2014 (South Australia has submitted only one application in this period).

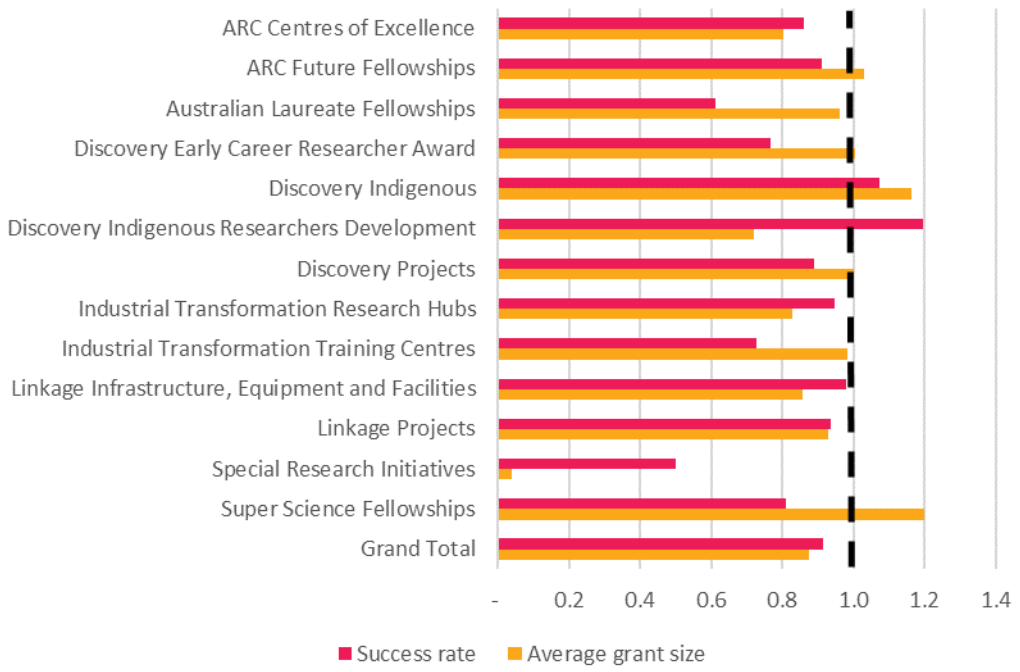
Since 2005, South Australian universities have submitted 6.7 per cent of applications and received 6.1 per cent of funding approved by the ARC. This is despite having between seven and nine per cent of Australia's academic staff, counted as person years of effort (PYE), devoted to research over this period.

> *The success rate for ARC grants is, of course, largely beyond the control of the ARC. It is a function of the demand for grants from the academic community, the cost of doing research at an international level and the resource available. The last component is dependent on the policy settings of the government of the day and to some degree the capacity of the sector to convince those controlling expenditure that the research undertaken within the sector provides value to the nation at large[42].*

The success rate and average grant size relative to the national average for each ARC program are presented in Figure 4.10.

[42] ARC, What is Success?, (2014), <https://www.arc.gov.au/news-publications/media/feature-articles/what-success>

Figure 4.10: South Australia's success rate and average grant size by ARC program, relative to the national average (national average = 1), 2010 to 2020



Source: ARC data, SAPC calculations.

South Australia's success rate was lower than the national average for all ARC programs except for Discovery Indigenous Researchers Development and Discovery Indigenous.

South Australia has historically received a smaller average grant size for the larger grants such as ARC Centres of Excellence (20 per cent lower than the national average) and Industrial Transformation Research Hubs (17 per cent lower).

Stakeholders have raised the issue of scale of South Australian universities as a limiting factor in receiving the more prestigious ARC grants, such as Centres of Excellence and Australian Laureate Fellowships which are awarded for excellence in a field. South Australian universities have had lower rates of applications than for Australia as a whole for both these programs. South Australia represented 4.8 per cent of Australian Laureate Fellowship applications since 2009 and 5.6 per cent of Centres of Excellence applications. South Australia also had a lower success rate for Laureate Fellowship applications (8.5 per cent compared to 13.8 per cent nationally), while Centres of Excellent applications had similar success rates to the national average.

Research quality and quantity

Research evaluation is increasingly being conducted using bibliometric methodology and citation analysis. Because no individual bibliometric indicator can account for all aspects of research performance, a selection of bibliometrics indicators are used to provide a broader view[43]. These metrics predominantly focus on volume (including type) and quality of outputs.

For academic publications, a common quality measure is the number of citations a publication receives, although other possibilities include the reputation of the publishing

[43] Clarivate Analytics, InCites Indicators Handbook, (2018), 8.

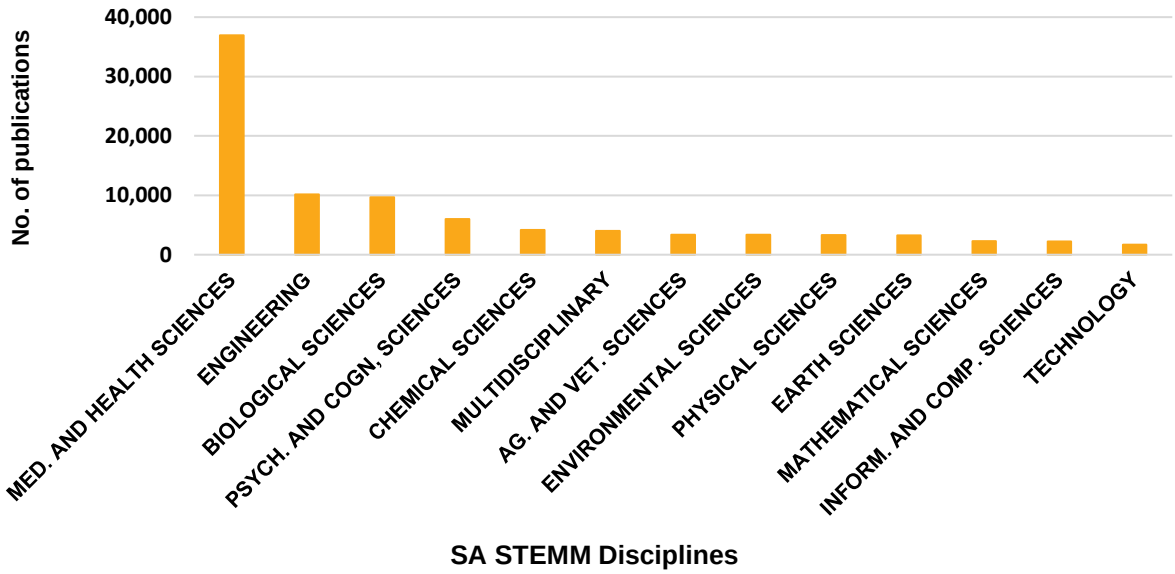
journal. How often global peers cite a research publication relative to others in the same field is a measure of the value of the work to potential collaborators and investors.

The Commission presents below selected quantity and quality indicators against relevant national and world standards.

Analysis by the Office of the South Australian Chief Scientist shows SA has the fifth highest share of total national STEMM research outputs between 2009 and 2018, averaging around 10 per cent. SA was ranked third for the quality of STEMM research outputs which were cited at a rate approximately 47.0 per cent higher than the world average. There has been an increase in the quality of STEMM research outputs from SA between 2013 and 2017.

Figure 4.11 provides a breakdown of the volume of research publications by STEMM disciplines in South Australia and shows that over the period 2009-18, almost 41 per cent of publications output came from the medical and health sciences discipline (this is consistent with other states), with engineering and biological sciences contributing 11.2 and 10.7 per cent respectively.

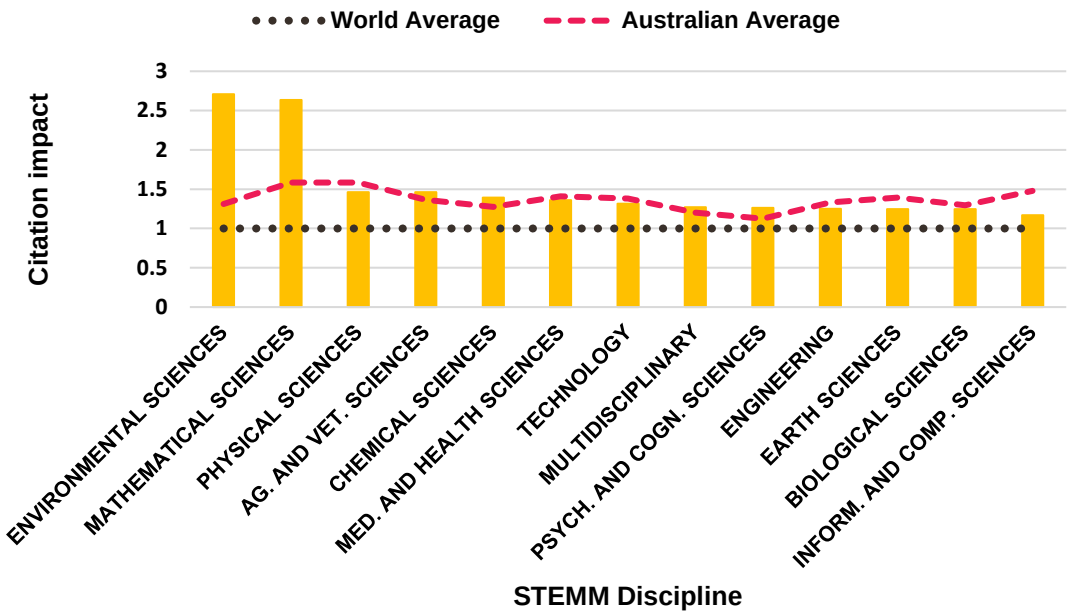
Figure 4.11: Volume of STEMM research publications by STEMM Discipline: SA, 2009-18



Source: South Australian Office of the Chief Scientist analysis of the Clarivate Analytics' Incites Journal Citation Reports system

As shown in Figure 4.12, SA performs well relative to the world standard in terms of research excellence for several STEMM research fields. Research outputs across SA STEMM fields attract higher citation rates compared to the Australian average in environmental sciences and mathematics. In trend terms, citation impacts of physical sciences, mathematical sciences, earth sciences, agriculture and computing sciences have been the noticeable improvers over the 10-year period.

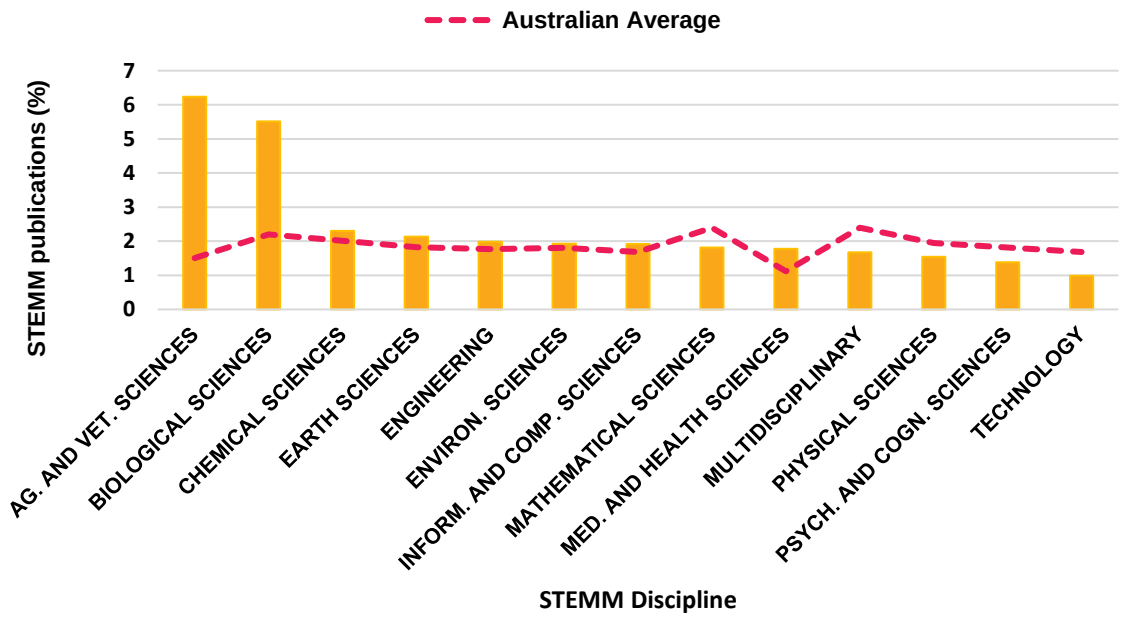
Figure 4.12: Category normalised citation impact of STEMM publications by STEMM discipline for South Australia, 2009-2018



Source: South Australian Office of the Chief Scientist analysis of the Clarivate Analytics' Incites Journal Citation Reports system

Figure 4.13 shows that in STEMM disciplines such as agriculture and veterinary sciences and biological sciences, South Australia performs well above the Australian average for the proportion of citations in the top one per cent of publications of the world.

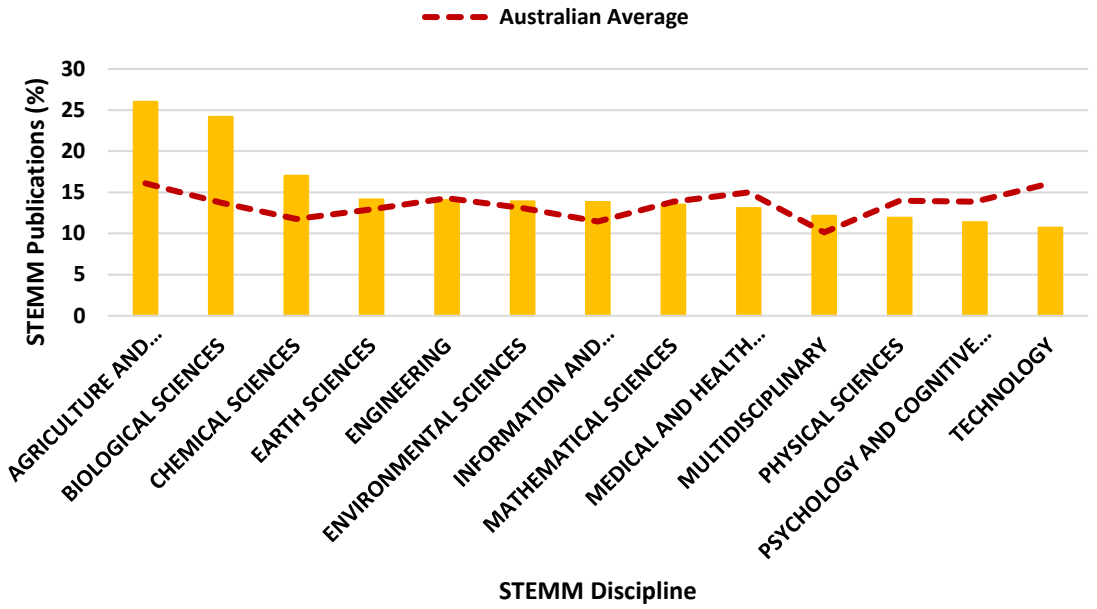
Figure 4.13: Proportion of STEMM publications by STEMM discipline in the top 1 per cent of the world: SA, 2009-2018



Source: Provided to the SAPC using South Australian Office of the Chief Scientist analysis of the Incites Journal Citation Reports system

Figure 4.14 shows that South Australia has similarly performing fields when outputs are extended to include the proportion of STEMM publications in the top 10 per cent of citations.

Figure 4.14: Proportion of STEMM publications by STEMM discipline in the top 10 per cent of the world: SA, 2009-2018



Source: Provided to the SAPC using South Australian Office of the Chief Scientist analysis of the Incites Journal Citation Reports system

Table 4.4 presents South Australia's share of Australia's higher education R&D inputs (expenditure and staff) used to produce outputs. South Australia had an average of 8.2 per cent of research staff and 6.8 per cent of Australia's HERD over this period. Therefore, South Australia could be said to be relatively specialised in any field that had a higher share of national expenditure and staff. These fields include agricultural and veterinary sciences, biological sciences, earth sciences and medical and health sciences.

Table 4.4: South Australia's share of Australia's higher education R&D inputs 2010-18 (%)

Field of Research	Expenditure	Staff
Agricultural and Veterinary Sciences	11.8	10.4
Biological Sciences	7.2	9.3
Built Environment and Design	6.5	7.1
Chemical Sciences	9.8	7.3
Commerce, Management, Tourism and Services	4.7	7.1
Earth Sciences	7.0	8.6
Economics	3.8	7.1
Education	4.2	7.7
Engineering	5.2	7.7
Environmental Sciences	7.6	8.1
History and Archaeology	2.6	8.1
Information and Computing Sciences	7.4	5.4
Language, Communication and Culture	3.6	8.0

Field of Research	Expenditure	Staff
Law and Legal Studies	1.7	6.5
Mathematical Sciences	5.2	8.2
Medical and Health Sciences	8.5	11.2
Philosophy and Religious Studies	1.5	6.6
Physical Sciences	4.1	6.9
Psychology and Cognitive Sciences	4.6	8.0
Studies in Creative Arts and Writing	4.6	6.5
Studies in Human Society	5.3	7.8

Source: ABS 8111.0, ARC data, SAPC calculations

Note: due to differences in publication frequencies, expenditure is the average expenditure for 2010, 2012, 2014, 2016 and 2018, while headcount is averaged for 2010, 2012, 2015 and 2018.

Excellence for Research in Australia performance

Methodology

The Excellence for Research in Australia (ERA) framework, administered by the ARC, is the national research evaluation framework for higher education institutions. The framework consists of international benchmarking for each institution and for each unit of evaluation, or research discipline, within an institution. The benchmarking is done against the following suite of indicators:

- citation analysis of distribution of papers on a world standard threshold relative to an Australian average as well as impact of the citation (using discipline specific-indicators);
- peer review of 30 per cent of citations nominated by the institution for each unit of evaluation (where appropriate thresholds of output are met);
- volume and activity of apportioned research outputs by frequency and type of output;
- research Income (number of grants and dollar amount of grants);
- applied measures
    - patents (number);
    - registered designs (number);
    - plant breeder's rights (number);
    - NHMRC endorsed guidelines (number); and
    - research commercialisation income ($);
- assessable outputs
    - traditional outputs (publishing profile of activity between books, book chapters, journal articles and conference publications); and
    - non-traditional outputs (research statements, creative works, public exhibitions and events, and research reports).

Some applied measures and non-traditional outputs do not apply to some fields of research and are not reported on by institutions; for example, measures relating to health grants, plant

breeder's rights or creative works will not apply to all areas of research. Where academic work crosses more than one research discipline, the output is weighted to appropriately reflect the division of research fields for that piece of work.

Citations results (analysis of impact and peer review) as well as the profile of citations take precedence with applied measures or other assessable outputs having the ability to raise ratings, but not lower ratings already achieved by citation output. If data is not held or the university does not meet thresholds for assessment, this does not reduce the overall rating. The methodology essentially allows institutions with differing levels of output to achieve the same rating[44].

ERA results for South Australian universities

Table 4.5 presents the results for South Australian universities of the ERA assessments conducted in 2010 and in 2018 as well as the category normalised citation impacts (CNCI) in SA to enable some comparison in performance over time[45]. The ERA scale ranges from five, being a high level of performance relative to the global standard to one, being a low performance standard. The results indicate an improvement over time of South Australian universities in almost all research disciplines with noticeable improvement in results across the three institutions in mathematics and physical sciences, engineering, psychology and cognitive sciences and medicine and health sciences. The CNCI scores also show improvements in almost all fields of research with the biggest improvements shown in mathematics and physical sciences.

Table 4.5: ERA results for South Australian universities in all research disciplines (2-digit level) for 2010 and 2018 and Category Normalised Citation Impact (CNCI) scores

Field of research	Flinders University		University of Adelaide		University of South Australia		CNCI (SA)	
	2010	2018	2010	2018	2010	2018	2010	2018
Mathematical Sciences	N/A	N/A	3	5	3	5	1.2	2.32
Physical Sciences	2	4	5	5	N/A	N/A	1.4	2.35
Chemical Sciences	3	3	3	5	5	4	1.1	1.41
Earth Sciences	3	3	5	5	N/A	N/A	1.23	1.35
Environmental Sciences	N/A	3	5	4	4	5	1.2	1.43
Biological Sciences	3	4	4	5	2	4	1.18	1.47
Agricultural and Veterinary Sciences	3	3	5	5	N/A	N/A	1.21	1.43
Information and Computing Sciences	N/A	2	3	4	2	3	1.02	1.34
Engineering	2	3	3	5	3	5	1.27	1.51
Technology	N/A	4	N/A	4	N/A	N/A	N/A	N/A
Medical and Health Sciences	3	4	5	5	3	4	N/A	N/A
Built Environment and Design	N/A	N/A	2	3	3	3	0.82	0.97
Education	2	3	1	2	2	3	0.8	1.11

[44] ERA Handbook states that: 'In all cases the quality judgments relate to all of the evidence, including the entire indicator suite, and the ERA rating scale. In order to achieve a rating at a particular point on the scale, the majority of the output from the Unit of Evaluation (UoE) will normally be expected to meet the standard for that rating point. Experience has demonstrated that there is normally a variety of quality within a UoE'.
[45] The ARC has indicated that the process to generate the 2010 results included some overlapping of research disciplines resulting in the higher of assessed scores being awarded in some instances.

Field of research	Flinders University		University of Adelaide		University of South Australia		CNCI (SA)	
	2010	2018	2010	2018	2010	2018	2010	2018
Economics	1	2	3	4	1	2	0.81	0.87
Commerce, Management, Tourism and Services	2	2	2	3	2	4	1.06	1
Studies in Human Society	3	3	3	3	1	3	0.75	0.82
Psychology and Cognitive Sciences	3	4	3	4	2	5	1.04	1.2
Law and Legal Studies	3	3	4	4	3	3	0.68	1.31
Studies in Creative Arts and Writing	3	4	5	4	3	3	0.51	0.38
Language, Communication and Culture	2	3	3	3	3	3	0.63	0.73
History and Archaeology	2	3	3	4	2	N/A	0.54	0.99

Source: ARC ERA Outcomes, accessed 02/07/2020 <https://dataportal.arc.gov.au/ERA/Web/Outcomes>

Measures of research productivity

Consistent with its terms of reference, the Commission also sought to understand the productivity of research including the link between performance and expenditure.

Measuring the performance of research is difficult, largely as a result of the difficulty involved with accurately measuring outputs and adjusting for quality. Not surprisingly, the Commission has been unable to identify commonly used measures of research productivity[46]. The Commission examined both the number of publications per million dollars of expenditure and the number of publications per staff member as potential partial productivity indicators[47]. The Commission notes that these measures cannot be used to compare across fields because of differing costs of doing research and different rates of publications between fields.

Table 4.6 shows the number of publications per million dollars of expenditure in each field for South Australia and South Australia's rank among mainland states. In seeking to also understand the production of quality publications, rather than just quantity, the Commission has also included the number of publications in both the top ten and one per cent globally by citations as a measure of output.

Table 4.6: South Australia's publications per $m and rank among mainland states, 2018

Field of research	Publications /$m	SA Rank	Top 10%/$m	SA rank	Top 1%/$m	SA rank
STEMM						
Mathematical Sciences	27.9	1	8.7	1	2.1	1
Physical Sciences	29.8	1	8.9	1	2.1	1
Chemical Sciences	17.5	4	2.9	5	0.6	4
Earth Sciences	23.9	1	4.3	2	0.5	2
Environmental Sciences	17.1	1	3.6	1	0.3	2
Biological Sciences	12.2	5	2.2	4	0.3	5

[46] There are a number of methodologies that have been applied in economic literature such as: G Abramo et. al. Comparison of research performance of Italian and Norwegian professors and universities, (2020), Journal of Informetrics vol.14 (2). However, these methodologies have not been commonly applied and data limitations have prevented the Commission from applying them to South Australian universities.

[47] Reliable staff data at the field of research level that is appropriate for such calculations was unable to be sourced; as a result, the Commission has not presented publications per staff member.

Field of research	Publications /$m	SA Rank	Top 10%/$m	SA rank	Top 1%/$m	SA rank
Agricultural and Veterinary Sciences	37.1	3	6.9	3	1.0	4
Information and Computing Sciences	21.6	5	4.1	3	0.6	4
Engineering	19.1	2	3.9	2	0.6	2
Medical and Health Sciences	19.4	3	3.0	3	0.6	3
Psychology and Cognitive Sciences	41.1	2	7.0	1	0.7	1
Non-STEMM						
Built Environment and Design	13.1	1	1.8	1	0.0	5
Education	11.7	1	2.0	1	0.4	1
Economics	8.4	4	1.1	3	0.1	3
Commerce, Management, Tourism and Services	9.0	1	0.9	5	0.2	2
Studies in Human Society	277.9	2	47.2	2	8.3	1
Law and Legal Studies	15.4	1	4.2	1	0.7	1
Studies in Creative Arts and Writing	2.9	5	0.1	5	0.0	3
Language, Communication and Culture	8.2	1	2.3	1	0.4	1
History and Archaeology	5.8	2	0.8	3	0.0	5
Philosophy and Religious Studies	24.1	1	1.5	2	0.0	4

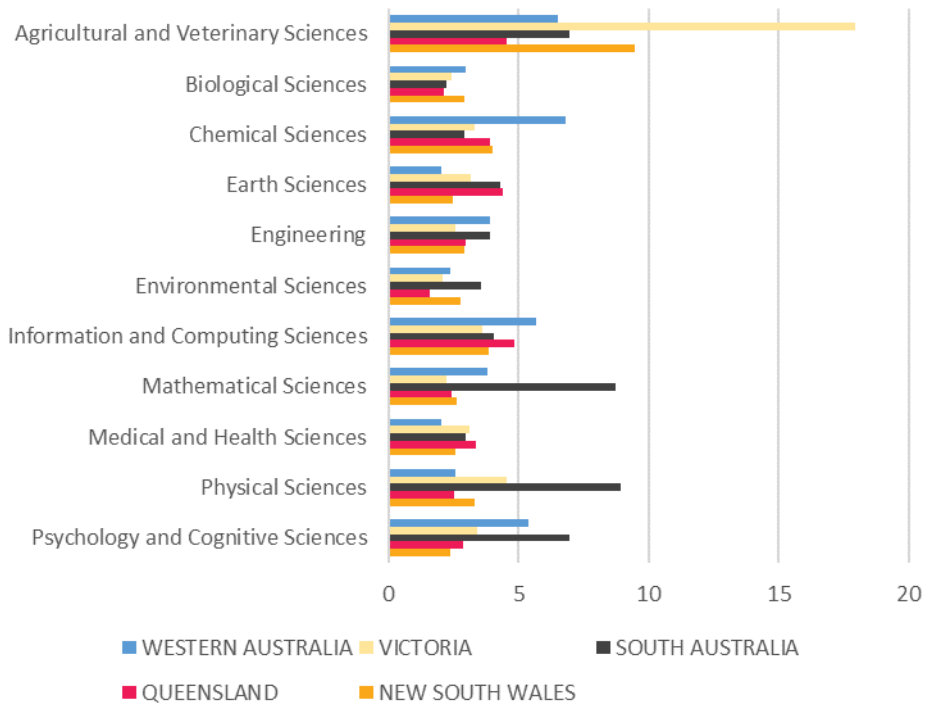
Source: Clarivate Analytics Incites database, accessed 02/09/2020, ABS 8111.0, SAPC calculations
Note: The Commission has defined publications in this context as only including articles, reviews and proceedings papers in the Web of Science database. The Commission understands that Web of Science documents are likely to represent a smaller proportion of total publications in the non-STEMM fields and some excluded outputs are likely to be more relevant in some non-STEMM fields. The table also presents both expenditure and publications from the 2018 calendar year, whereas much of the expenditure related to these publications is likely to have occurred in previous years. Also note that the Clarivate database uses the updated ANZSRC 2020 fields, while the ARC and ABS data use the ANZSRC 2008 classifications. The mapping of some fields from the ANZSRC 2020 to 2008 fields do not have a direct concordance.

Universities have suggested that while these measures are useful, total publications per million dollars of expenditure is not an accurate measure of productivity as not all publications are of equal value. Further, for some fields, especially non-STEMM fields bibliometrics data was not seen as a good measure of output. Generally, universities preferred the number of publications in the top ten per cent per million dollars of expenditure, with the top one per cent seen as excluding too much output.

These measures suggest that in most STEMM fields South Australian universities were among the most productive of Australia's mainland states in 2018, ranking in the top three for publications in the top 10 per cent per million dollars in all but two STEMM fields. South Australia performed particularly strongly in mathematical and physical sciences, ranking first in all three measures.

The distribution of the number of publications for STEMM fields in the top ten per cent per million dollars of expenditure among Australia's mainland states is presented in Figure 4.15.

Figure 4.15: Number of publications in the top 10 per cent of citations per $m, by state, 2018



Source: Clarivate Analytics Incites database, accessed 02/09/2020, ABS 8111.0, SAPC calculations

4.3. Stakeholder feedback

Regarding measures of the impact of R&D on the South Australian economy, universities monitor the growth and regeneration of enterprises and the arrangements for translation and commercialisation partnerships involving individual researchers or groups. The monitoring of commercialisation and translation includes licensing revenue and IP protection.

Flinders University highlighted the importance of indicators other than economic measures, emphasising the importance of standardised indicators of social progress such as:

- mental health and wellbeing;
- social indicators, as measured by the OECD, such as equity, self-sufficiency, physical health and demographics; and
- indicators of social progress assessing access to foundational services to meet basic needs, such as education, communications and healthcare and social opportunity.

In terms of measures of public research, the university sector has identified the number of employees dedicated to external R&D relationships and the number of collaborative R&D projects as an alternative way to quantify inputs and understand the result of R&D efforts. Universities see R&D measures such as publications, grant funding, and Higher Degree by Research (HDR) completions as essential:

- in attracting Research Block Grant funding from the Australian Government (a time-lagged, performance-based measure to supplement the cost of research);
- to building the necessary skills and expertise to expand fields of research ('success leads to success'); and

- in creating and maintaining a reputation for research excellence (necessary to attract external investment, high-quality researchers and students).

International higher education institution ranking schemes can also have a considerable influence on the perception of an institution by students, researchers and industry, affecting its ability to attract the necessary inputs to grow and be successful. The most recent results for three of the most commonly used ranking indicators are detailed in Table 4.7.

Table 4.7: Global university rankings in 2019, selected ranking indicators for South Australian universities

Ranking Indicators	University of Adelaide	University of South Australia	Flinders University
Times Higher Education	120	251-300	251-300
QS World University Rankings	106	274	424
Academic Ranking of World Universities	137	501-600	401-500

Source: Times Higher Education Rankings, Quacquarelli-Symonds World University Rankings and the Academic Ranking of World Universities.

The most commonly cited measure of research excellence in Australia is the ERA. The university sector considers the outcomes of the ERA scheme to be influential on staff recruitment and the strategic allocation of HDR scholarships. While influential, the ERA results are tempered by other factors in decisions about research priorities. Universities also consider factors such as societal challenges and needs, national and/or funding body priorities, economic opportunities and competition with other institutions.

Other measures that were identified related to pure innovation measures and the effects of R&D on innovation. Examples include rate of technology adoption or age of technology assets (the extent to which a business employs technology or knowledge that was not available one year or five years ago), IP applications filed and the revenue (or employment) growth of startup businesses.

4.4. Conclusions

The Commission analysed the performance of SA relative to other jurisdictions on aspects of R&D that are considered critical for economic growth. In summary:

- SA underspends on intellectual property capital formation compared with other Australian jurisdictions as measured through the national accounts.
- South Australia has the third highest BERD to GSP ratio of any state but it is significantly lower than the Australian average (0.74 per cent compared to 0.9 per cent).
- South Australian businesses are more likely to undertake R&D than the national average. The average spend per firm being lower in South Australia likely reflects the state's higher proportion of small firms.
- South Australia's industry structure also results in lower business expenditure than would be expected if industry structure matched the national total, with the South Australian economy having a higher proportion of business in sectors with lower R&D intensity. This structural effect reduces South Australia's R&D intensity by $16,100

per million dollars of R&D, with lower intensity within sectors contributing a further $1,700.

- With respect to university research, South Australia's performance seems comparable to other states when it comes to the use of bibliometrics. South Australia exceeded the national average for: CNCI scores in six (out of eleven) STEMM fields; the proportion of articles in the top one per cent in eight; and the proportion of publications in the top ten per cent in seven. South Australia also appears to have been improving, with CNCI scores improving in all but three fields from 2010 to 2018 and ERA scores generally increasing over this period.
- South Australian universities were generally less likely than the national average to apply for ARC Discovery program grants, but more likely to apply for ARC Linkage program grants. Success rates were also lower for most schemes. South Australian university income from ARC competitive grants appears to be limited mainly by lower application rates, and smaller average grant sizes for the larger grants such as Centres of Excellence.

The implications of the lower private sector spend and what options the state government has in promoting and incentivising more R&D expenditure by local businesses are discussed further in Chapter 7. Options for the state government include direct expenditure (e.g. procurement policy or other financial support), asset management strategies and building partnerships with others (e.g. Australian Government).

Possible explanations for South Australia's lower grant application rates, success rates and average grant size are discussed in Chapters 6 and 7, with possible explanations including the lack of scale of South Australian universities as well as appropriate leadership.

5. Factors affecting R&D performance: infrastructure, funding and access to data

This chapter focuses on the physical and financial issues affecting the state's R&D performance (as identified in the terms of reference). These factors are:

- infrastructure;
- funding available to research organisations and businesses at various stages of the research, development and adoption processes; and
- access to data and efficiency of collection and acquisition of information in the context of changes in the technology of research methods.

5.1 Infrastructure

5.1.1 Introduction

The section on infrastructure addresses the issue of the level and effectiveness of expenditure on infrastructure by the South Australian Government. The investigation also looks at the suitability of investments in infrastructure for use by the state's researchers and businesses.

The majority of the significant infrastructure assets in South Australia are housed within the higher education institutions and state-based operations of national research organisations funded and operated by the Australian Government. The South Australian Government also has considerable research capability in primary industries through SARDI.

Overview of state government's infrastructure expenditure

The Commission sought details from state government agencies of current R&D assets either in support of their own R&D or of R&D outcomes of other sectors of the economy. The financial data reflects the state government contribution to the cost of the asset and is in current dollars at the time of expenditure and has not been depreciated. No time period was set for when the expenditure was undertaken as many of these assets have a significant life span with expenditure on significant current assets occurring decades ago.

The financial data provided by agencies is built on varying understanding of R&D and has been difficult to retrieve and summarise in usable forms, and in some cases is not able to be quantified. Consequently, the exercise has been very challenging for agencies. The information presented in Table 5.1 is a summary of all current assets that agencies consider support R&D; it has not been filtered or amended by the Commission.

This development of a register of assets has been a significant undertaking for SA Government agencies. The register can be refined, maintained and updated to provide an authoritative statement of the state government assets that support R&D activities. Such information is highly relevant to a strategic approach to research, development and innovation.

The largest infrastructure investment by state government to support R&D has been associated with innovation and science precincts. The state government has invested

$290.2 million[48] in infrastructure, mainly in the form of buildings, at innovation precincts since the construction of Technology Park. (These costs do not include some expenditures, such as site remediations, which in some cases have been significant).

SARDI's investment in R&D infrastructure has also been significant, particularly in equipment, which constitutes 95.7 per cent of the total state government investment equipment. SARDI infrastructure supports activity in aquatic sciences, crop and food sciences and livestock science. SARDI presented the Commission with details of approximately 1,000 individual pieces of infrastructure indicating a large and comprehensive investment.

Table 5.1: Register of SA Government R&D infrastructure, estimate of state government expenditure on current assets

Government agency	Buildings	Data collections	Equipment	Machinery	Specialised software	Total
	$	$	$	$	$	$
AGD	-	-	-	-	1,947,000	1,947,000
DEW	357,190	-	1,121,000	-	-	1,478,190
PIRSA	20,314,535	5,477,536	75,767,122	14,699,475	596,313	116,854,981
Renewal SA	290,175,388	-	-	-	-	290,175,388
SA Health – CAHLN	18,000,000	-	2,294,287	-	-	20,294,287
Total	328,847,114	5,477,536	79,182,409	14,699,475	2,543,313	430,749,847

Source: Information provided by SA Government agencies on request from the Commission

Note: SAMHRI is not included in the estimate of expenditure as it is not a South Australian Government asset.

Overview of the state government's R&D infrastructure policy

As discussed in Chapter 2, in October 2020, the South Australian Government released the EXCITE strategy—a 10-year science and innovation strategy designed to attract research investment and take South Australian products and services to global markets[49].

The EXCITE Plan also highlights the need to build a South Australia 2030 Horizon Major Research Infrastructure and Technology Roadmap to support researcher and industry access to infrastructure.

5.1.2 Stakeholder feedback

Awareness of the state's R&D infrastructure and its capabilities has been raised as an issue by businesses. Business stakeholders located at the precincts have told the Commission that the standard of infrastructure is very good but the industry base to draw upon it is small. The attraction of businesses to an innovation hub and the likelihood of being successful there depend in part on their level of integration into research activities.

University submissions to the draft report have emphasised the importance of innovation precincts and the importance of physical proximity of researchers to business. The submissions point to widely recognised benefits of such proximity:

> *These benefits have both tangible and intangible elements. Industrial precincts are drivers of future R&D through the 'spill over' of knowledge between firms and industries. In the United States and United Kingdom, surveys of firms have shown the value businesses place on informal interactions*

[48] The number includes estimated expenditure on buildings currently being constructed at Lot Fourteen.
[49] <https://innovationandskills.sa.gov.au/science/excite-strategy>

with universities, and the ease of access that open forums provide for these interactions (Flinders University submission, FR2, p6).

In meetings with the Commission, the universities have indicated that the model of research precincts, when well-established and operated, is an effective model. A clear state government vision to develop and link the various precincts across South Australia is nonetheless required to ensure the infrastructure meets expectations of industry and researchers. The constant construction of precincts and subsequent focus on the most recently established research precincts has detracted from the focus of the node established prior to that, diluting the effectiveness of research infrastructure already in place.

Further, the universities have, in discussions with the Commission, indicated that reforms are required to improve the outcomes of the operations and activities of innovation precincts. These reforms relate to focus of activities in relation to state priorities, identification of success factors and measurement of progress.

Both university and business stakeholders see a key challenge is to spread the culture of collaboration and the innovation ecosystem beyond the boundaries of the innovation precincts.

5.1.3 Large-scale infrastructure

The National Collaborative Research Infrastructure Strategy (NCRIS) is a national network of world-class research infrastructure projects that support high-quality research expected to drive greater innovation in the Australian research sector and the economy more broadly. Projects support strategically important research through which Australian researchers and their international partners can address key national and global challenges.

The NCRIS network currently supports national research capability through 23 active projects. The majority of the projects have nodes spread across Australia — around 50 per cent are located in Australia's universities with the Group of Eight Universities hosting nearly three-quarters of university-based NCRIS facilities. Table 5.2 indicates that South Australia performs well is attracting NCRIS projects to the state, particularly research nodes, with 22.2 per cent of national nodes in the state.

Table 5.2: Location of NCRIS projects by state

State	No. of lead facilities	No. of nodes	National share of lead facilities (%)	National share of nodes (%)	Population share of Aus. (%)	Proportion of national academic research staff 2016 (%)
ACT	4	5	17.4	13.9	1.6	5.2
NSW	4	5	17.4	13.9	31.7	29.7
QLD	3	6	13.0	16.7	20.0	18
SA	1	8	4.3	22.2	7.0	7.8
TAS	2	1	8.6	2.8	2.0	3.1
VIC	7	4	30.4	11.1	25.8	27.7
WA	2	7	8.6	19.4	10.1	7.9

Source: Australian Department of Education, Skills and Employment

South Australian Facilities

The Australian Government does not track projects or nodes by state over time and the Commission was unable to find definitive advice about previous NCRIS facilities in South

Australia. Two projects with SA nodes had NCRIS funding withdrawn following the 2016 National Research Infrastructure Roadmap:

- 'Biofuels' – This project had two nodes including Algal biofuels operated by SARDI.
- 'Groundwater' – This project had multiple sites including monitoring of Willunga Basin by Flinders University.

Currently SA hosts one lead project — the Australia Plant Phenomics Facility at the University of Adelaide's Waite Institute. The 2019-20 State Budget provided funding of $19.6 million over six years to support six South Australian-based NCRIS facilities and nodes to: purchase new (or upgrade existing) research infrastructure; complete minor capital works; and provide operational support for staff positions. A seventh facility receives in-kind support.

5.1.4 Innovation and science precincts

Historically, research and development providers have operated using collaborative models in which universities, research institutes, government organisations, not-for-profit groups and business are co-located in science parks and innovation precincts.

While not exclusively R&D focused (precincts are also commercial hubs, providing commercial leasing and business support); the precincts are a base for government, university and business entities to engage and collaborate in R&D.

Several innovation and science precincts operate in South Australia. Some of these are operated by the state - Mawson Lakes Technology Park, Tonsley Innovation District, and Lot Fourteen.

The state also has a presence in the Waite Research Precinct through SARDI and has a presence in Adelaide BioMed City (ABMC). ABMC is a new HMR precinct being developed with funding from the Commonwealth, and is a collaboration between SAHMRI, the University of Adelaide, the University of South Australia, and the Central Adelaide Local Health Network among others.

Renewal SA has an overarching role in the establishment and management of the innovation and science precincts that varies with each precinct. With respect to Lot Fourteen, Renewal SA is currently the commercial advisor and master developer; for an established precinct such as Tonsley, the role is to deliver value for the physical assets.

Overview of precincts in South Australia

The most recent development of this policy has been the establishment of place-based innovation districts engendering a more collaborative and complete innovation eco-system to support all aspects of developing and commercialising knowledge by connecting educators and researchers. Lot Fourteen and the Tonsley Innovation District were established using this type of model. The Adelaide BioMed City precinct is a hub for health and life sciences located in the Adelaide CBD; the activities of this precinct were addressed in the Commission's inquiry into health and medical research.

<u>Mawson Lakes Technology Park:</u> is an economic development site for technology-related businesses. There are currently 69 tenants in the two buildings managed by Renewal SA whose activities include information technology, defence, design, engineering and technology support with startup businesses.

Thebarton Bioscience Precinct: the site consisted of five specialist research and manufacturing facilities and five hectares of land under management within a bioscience precinct, shared with the University of Adelaide. Two specialist bioscience business incubators, formerly through Bio Innovation SA (now TechinSA), offered business assistance and research and office space to early-stage companies to accelerate their growth. TechInSA is currently being wound down, with services for entrepreneurs and startups moved to the Office of the Chief Entrepreneur[50]. Tenancies at the Thebarton Bioscience Precinct will be honoured until their contracted end date.

Tonsley Innovation District: The former Mitsubishi site at Tonsley has become a precinct of cleantech, sustainable technologies and environmental industries, advanced manufacturing and research and development.

Tonsley is a key site for Flinders University to engage with government and industry in accelerating the uptake and diffusion of advanced technologies and skills in the state. Flinders has undertaken a large investment in the development of the site including an extensive network of laboratories and teaching spaces. The Flinders at Tonsley campus along with Tonsley TAFE and the Drill Core Reference Library are anchor institutions, designed to attract knowledge intensive firms and startups.

Tonsley's model incorporates the development of high amenity, mixed-use urban development (physical assets), populated with anchor businesses as well as research and training institutions (economic assets) in an environment that supports entrepreneurial activity and a culture of innovation (networking assets) to create an innovation district.

Lot Fourteen: is an innovation incubator and business startup and growth hub located at the former Royal Adelaide Hospital site on North Terrace. It is backed by the South Australian and Australian governments and is a key focus of the Adelaide City Deal initiative to provide a base for increasing innovation in the state. The site will add to and engage with the surrounding education and innovation precinct, partnering with institutes and research capability of the University of South Australia and the University of Adelaide.

The precinct is in the late stages of renewal and construction with the final assets forecast to be completed by mid-2021. The precinct's activities are intended to align with strategic sectors relevant to the state government priority growth sectors of defence and space, cyber security, food and wine, medical technologies, robotics, media and film.

Waite Research Precinct: The Waite Research Precinct co-locates the agricultural research capability of the University of Adelaide with other research organisations such as SARDI, AWRI and CSIRO. The Waite Research Institute (WRI) was established in 1924 and supports the University in developing and funding strategically important initiatives and by building research capacity and performance. The WRI also supports the University and its partners by providing a 'front of house' service and central coordination point for communications. See Chapter 6 for a detailed discussion of the Waite precinct.

Framework for assessment of precincts performance

The Commission's evaluation of the innovation precincts is focused on their stated R&D and research engagement objectives. The Commission evaluation has relied on the information and feedback provided by business and university stakeholders and is intended to highlight

[50] 2018-19 Budget Measures Statement, p. 100; Premier of South Australia, 'SA's New Entrepreneurship Model', Media Release (2018).

the gaps in performance and options to address those gaps. The evaluation of precincts has examined:

- whether the precincts collectively have, efficiently and effectively, achieved outcomes relative to their stated objectives;
- to what extent are they valued by stakeholders;
- what lessons have been learned to optimise the value of current and future investments in relation to R&D and commercialisation; and
- how they contribute to lifting SA's economic growth and productivity.

To help answer these questions, the Commission has applied the Brookings Institute's framework for the assessment of the precincts[51], which was developed from an analysis of globally recognised innovation precincts.

The key factors are summarised in Appendix 3 with elements such as leadership, collaboration and capacity. The Commission's assessment of South Australian precincts considers, among other factors, the presence of the requisite elements for effective operation, when these factors were implemented and what the results have been.

This assessment has been constrained by limited or absent information. The Commission has been unable to make a thorough assessment of the effectiveness of the precincts with respect to support for R&D activity, notwithstanding further consultations following the findings of the draft report.

Performance of precincts

The stated policy objectives for establishing innovation precincts in South Australia have been:

- the activation of public space triggered by the re-location of the Royal Adelaide Hospital (Lot Fourteen);
- filling the void of a major company closure and attempting to activate key emerging sectors based on local company success (Tonsley); and
- the requirement to remain globally relevant and competitive (Thebarton Bioscience precinct).

The vision for Tonsley is a centre of cleantech, sustainable technologies and environmental industries, advanced manufacturing and research and development. The vision includes the expectations that: Tonsley be an integrated, mixed-use site that adds to and engages with the surrounding education and innovation precinct; accommodates a significant number of quality jobs; develops as a transit-oriented hub; demonstrates best practice urban design and building principles; and evolves as an iconic brand for southern Adelaide.

The vision for Lot Fourteen, at the former Royal Adelaide Hospital site on North Terrace, is to be an innovation incubator and a business startup and growth hub. Lot Fourteen is also expected to support: investment attraction; employment and business growth integrating mixed use of land in collaboration with universities; and the activation of public spaces.

[51] The Brookings Institution, Assessing your innovation district: A how-to guide, The Anne T. and Robert M. Bass Initiative on Innovation and Placemaking (2018).

These two precincts differ in focus from the earlier Mawson Lakes and Thebarton precincts, which were very much focused on business and industry development. Tonsley and Lot Fourteen have only been recently established and the benefits accrue over time. As such, the assessment of the precincts needs to recognise their current stage of development.

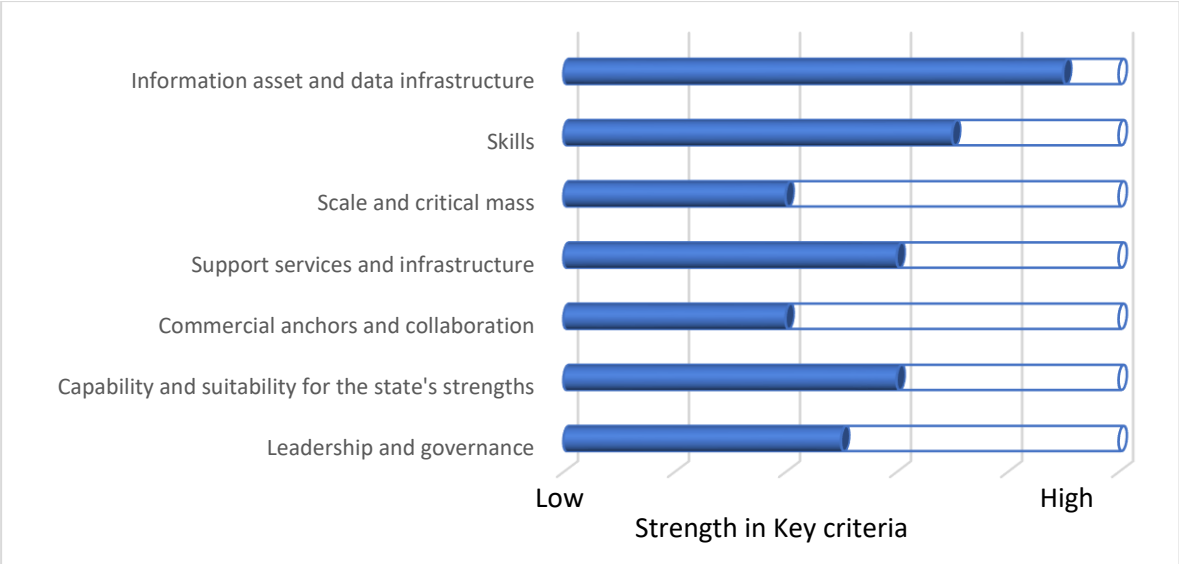
Figure 5.1 depicts the results for seven assessment criteria applied to the active precincts operated by the state (Mawson Lakes, Lot Fourteen, and Tonsley). The information presented is based on a rolled-up assessment for all three precincts (more detail is provided in Appendix 3). They combine specific information and subjective judgement of the Commission.

The more noticeable areas of weakness in design and practice of the state's innovation precincts, compared with the literature describing global innovation precincts, is the sense that these precincts:

- are not established for economic purposes that are well communicated, well understood and have widespread buy in;
- do not align well to the region's comparative market advantages at the time the precincts were established; and
- have a mode of operation that aims to achieve a broad suite of policy objectives rather than a more focussed and measurable set of objectives.

In addition, documentation provided by Renewal SA to the Commission indicates the interaction between stakeholders and precinct managers has been confined to physical accommodation issues rather than a consideration of strategic issues to improve the effectiveness of precincts.

Figure 5.1: Summary of Commission assessment of innovation precincts



Source: Constructed by SAPC based on assessment against the Brookings Institute framework.

State agency views on performance of precincts

In response to internal reviews of precinct operations and the findings of the Commission in the draft report, Renewal SA has emphasised the recent reforms made in relation to governance, sustainability, return on investment for commercial partners, the importance of

collaboration and the need to develop a long-term vision related to the state's long-term economic needs. These reforms include the appointment of a precinct director to focus on collaboration and governance and a greater focus on whole-of-precinct governance rather than project management.

Renewal SA has emphasised to the Commission that these precincts are not homogenous and are individualised to needs. Measurement of progress and feedback mechanisms for improvement in governance and operation are at the forefront of the most recently established precincts. Renewal SA is establishing benchmarks for precinct operations and assessment.

In documentation provided to the Commission, precinct project managers have stressed the importance of avoiding competition between the various science and innovation precincts to avoid 'cannibalising' the resources and research programs in other precincts.

State government project managers have also emphasised to the Commission the global nature of the competition; the competition may not be with the precinct nearby but with precincts in other regions and countries. Project managers prefer that tenants have an established connection or the ability to establish a connection to the researchers and the industries in which they operate.

A key area of attention for project managers in the future will be the accessibility and attractiveness of an area in addition to the infrastructure. While drawcards within the precinct attract initial attention, project managers consider there must be more substance to maintain interest. The substance of the precinct in terms of what it has to offer tenants is important in generating growth and collaboration in the longer term. To support this outcome, activities and initiatives have focused on investment attraction, the development of support sectors such as hospitality and retail and the commercial viability of tenants.

Box 5.1: Case study of the Tonsley Innovation Precinct

Tonsley Innovation Precinct

The Tonsley precinct became fully operational in 2014-15. Current project cash flow forecasts indicate that the state government will commit $333.9 million, including $246.6 million in capital expenditure. Projected revenue received over the life of the project is $248.9 million. To date the precinct has reported financial losses of $53.4 million in 2015-16, $35.9 million in 2018-19 and $18.3 million in 2014-15.

Initially, Tonsley focused solely on 'green tech' industries. This has been refined to four categories – cleantech and renewable energy; automation, software and simulation; mining and energy services; and health and medical devices. The land area is divided between high value manufacturing/industrial (50 per cent), commercial and residential (both 20 per cent) and retail and education and research (10 per cent).

Tonsley has production facilities, R&D facilities, retailers, student accommodation buildings, educational facilities and a 'Co-Hab' working space that provides support for business to build and grow companies and bring innovations to market.

The number of businesses has grown from 5 in 2013-14 to 35 businesses in 2018-19 (including SAGE Automation, Zeiss and ZEN Energy). Employment has grown from 265 to 1,749 in 2018-19. The significant employers are Flinders University with 235, Mitsubishi and TAFE SA with 200 and SA Health with 120 employees. There are also

8,200 students at the precinct (6,200 TAFE students and 2,000 university students). Most businesses (68.6 per cent) on the site have less than 20 employees,

Renewal SA tracks investor tours of the precinct and economic development events, strategic partnerships and investor introductions. Based on the information reviewed, the Commission notes that investor tours, economic development events, investor assistance and partnerships have occurred on a consistent basis since 2015.

A benchmarking report of the Tonsley precinct undertaken by Renewal SA identified areas for future reforms to be addressed in collaboration arrangements, governance structures and precinct amenities. While these areas have been addressed in a structural sense through the appointment of a precinct director and a change in governance structure, the reforms associated with collaboration and promotion of innovation within the precinct are still be addressed.

Measures of success were compiled in a benchmarking report undertaken for Renewal SA by SGS Economics and Planning in 2016; however, these are not being tracked.

Source: Based on documents provided to the Commission by Renewal SA

Performance from stakeholder perspective

Businesses located at the precincts have told the Commission that the capacity and capability of infrastructure available for emerging sectors of the economy is seen as ample to the extent that no more is required. The quality of the infrastructure is well regarded locally and by researchers and business visitors from interstate or overseas.

Meetings with business stakeholders, particularly startups, have emphasised the need to focus on industry capability and soft infrastructure such as skills and research quality, rather than continued expenditure on physical innovation and R&D infrastructure, which has been the focus of large expenditure commitments in the last ten to twenty years.

Startup businesses have struggled to come to terms with precincts offering rental space at commercial rates when there was already an oversupply of rental space. While short-term incentives, including rental discounts have been offered for short periods of time, the incentives are not ongoing. The counterbalance to commercial rental rates is extracting value from amenities, services and facilities at the precinct and this value has not materialised in many cases. Discussions with business startups have identified an alternative strategy of giving a ‘leg-up’ to startup enterprises and local companies through lower rentals specifically for R&D businesses to encourage their growth.

University stakeholders have confirmed the initial conclusion of the Commission that more must be made of the state’s investment in precincts with reforms needed in measures of success and focus of activity. Flinders University states that:

> *The challenge for the State going forward is to be clear about what the critical success factors are for thriving and productive precincts, informed by both local and international evidence and experience. (Flinders University, FR2, p5)*

5.1.5 Findings and recommendations

General remarks

The Commission considers that a central register of infrastructure, maintained by the state government with input from universities, business and relevant industry bodies, would be

useful in understanding the scope and magnitude of the state's R&D assets. To make the register practical, it is recommended that the list is limited to key pieces of infrastructure. A visible register would promote better engagement between businesses, individuals and organisations who are interested in using the infrastructure more effectively. The form of the register would be a matter for the state government; it must be accessible and have links to critical providers, contacts and infrastructure programs.

Gathering information on the extent and function of R&D infrastructure in the state has been a time-consuming and unsatisfying exercise. Further, the delineation between state operated or funded, privately owned infrastructure or infrastructure operated by higher education or Australian Government research institutions is in some cases unclear. Without publicising the existence of key pieces of infrastructure and associated capabilities, underuse of facilities and lesser research outcomes are the likely result.

The University of Adelaide has reinforced to the Commission that the realisation of opportunities to make better use of research infrastructure must be supported by effective research partnerships.

The Commission notes that the Office of the Chief Scientist of South Australia will establish the 2030 SA Major Research Infrastructure and Technology Steering Group in 2021. The Commission supports the establishment of this group and that it may be best placed to manage the register and its establishment.

Recommendation 5.1: Central information register of R&D infrastructure

The Commission recommends that the state government, in cooperation with universities and industry, develops, maintains and promotes a register of key research and development infrastructure (including national infrastructure networks) available for use in South Australia.

The Commission heard from stakeholders of a lack of coordination of state and national R&D infrastructure priorities and the effect that this has on leveraging Australian Government funding. Australian Government involvement is critical in delivering relevant infrastructure for business and emerging growth sectors to use in the state.

Developing and clearly communicating priorities in infrastructure is critical for several reasons. Alignment of state and national priorities is important to efficiently scale up resources. Coordination of effort enables duplication to be avoided, gaps to be analysed and addressed, and ensures the capabilities of the sectors using the infrastructure match the capabilities and capacity of the infrastructure.

The Commission concludes there is a significant opportunity for the state to engage better with the Australian Government on R&D assets in terms of aligning priorities and leveraging increased amounts of funding for infrastructure assets of need for the business community.

The Commission notes that the state infrastructure plan includes priorities on R&D infrastructure and further that the Office of the Chief Scientist has a key outcome of a research infrastructure roadmap to articulate future investment needs and drivers. (The EXCITE Plan, released by the Chief Scientist in October 2020, highlights the need to build a South Australia 2030 Horizon Major Research Infrastructure and Technology Roadmap to support researcher and industry access to infrastructure).

The Commission agrees with the value of such a plan. It considers that this process will be enhanced by developing state-wide priorities in collaboration with end users and built to ensure maximum use and benefit of R&D infrastructure inside precincts, universities, state government departments and critical national infrastructure nodes. At present, the state government lends support to proposals prepared by individual institutions or for individual projects once bids are developed rather than having a proactive and strategic approach.

The Commission has been provided with examples from individual sectors and from arrangements in other jurisdictions where the leveraging of Commonwealth funding has provided tangible benefits. The common features of the initiatives include: scale of programs and resources allocated; common areas of purpose between state and Commonwealth; length of programs; and a focus on end-use, impact and innovation. This has resulted in some significant benefits in leveraging Commonwealth funds in other jurisdictions in manufacturing and the food and beverage industries.

The Commission notes that a STEMM and Innovation Cross Agency Working Group has been in operation since July 2019 with responsibilities for engagement with state and federal research and innovation partnerships, priorities and funding opportunities.

This Working Group has provided a forum for information exchange on national and state-based research and innovation partnerships, priorities and funding opportunities including:

- CSIRO's national challenges and missions
- National Collaborative Research Infrastructure Scheme (NCRIS)
- Cooperative Research Centre Programs and Projects
- Defence StarShots Program
- The Australian Science Media Centre and its relevance for SA government agencies.

In Chapter 7, the Commission will develop recommendation to develop stronger partnerships with the Australian government and other research partners.

Innovation and Science precincts

In relation to South Australian Government innovation and science precincts, the Commission found:

- the standard of infrastructure and facilities of the buildings at the state's innovation precincts is well regarded and in many cases is of national or global standard.
- the ability to attract anchor institutions and national nodes of research is high and industry interest in the precincts in selected industries such as defence, medical and IT is high.
- planning of precincts and development of multiple uses of land has been well organised and executed.
- clear responsibilities have been allocated for the management of precincts.

And weaknesses:

- the incentives provided to tenants, access to resources, services and formal collaboration with researchers and amenities do not offset the costs of tenancy, which are usually at commercial rental rates.
- collaboration arrangements and programs at the precincts are not measured or reported on effectively.
- while there are links to state government strategies, there is no real depth in engagement, functional responsibility and allocation of resources to specific outcomes. This is the case also in linking to national priorities and funding programs.
- there is an absence of strategy for growing the interactions within the precincts, improving the quality of services offered to tenants and how to treat businesses once they grow beyond the startup phase.
- there needs to be improvement in the individual strategies of precincts so that they fit better together and have regard to the R&D and innovation landscape in the state.

While the Commission accepts that there is value in proximity, the cost of attempting to generate that outcome matters as do the collaboration outcomes themselves. Most R&D in the state is generated by businesses and researchers not located or connected to precincts. The mechanisms that support R&D need to be proportionate to the mechanisms that create R&D. Accordingly, collaboration, skills and government support programs need to be far more focused and effective.

The Commission concludes there are elements of excess capacity in the R&D infrastructure of the state in comparison to the number of companies that could make use of it. This is not universal across precincts. The financial models used to construct infrastructure precincts do not encourage and support broad-based participation by businesses either inside precincts or to encourage businesses outside precincts to access services and infrastructure provided.

Businesses have told the Commission that the offer and existence of services at precincts is a major drawcard. These services are said to be a critical incentive to participation in the precinct for businesses and a necessary counterbalance to the payment of market rental rates for tenants.

The Commission has found that the amenities, innovation services and formal collaboration structures offered at precincts are not fully integrated with the operations of the precinct and in some cases are absent. The allocation of responsibilities at the precincts is clear in terms of operational aspects of precincts in contrast to the more strategic aspects oriented toward R&D goals which, in the information provided to the Commission, is unclear.

On the key question of the extent to which the precincts have been successful in businesses achieving closer engagement with, and access to, relevant top research capability in the associated research institutes, the assessment has been constrained by limited quantitative information on the costs of building and operating the precincts, the cost of alternatives to on-site collaborations and the expected research and development benefits.

The Commission concludes that precincts in South Australia, as pursued historically and as a policy instrument for research and development, are inefficient instruments with limited effectiveness in stimulating additional applied research and commercialisation.

Based on research and documentation provided, the Commission found that access to funding and awareness of research infrastructure are critical variables in the take-up and

effective use of research infrastructure. Publicly provided infrastructure is available and adequate for industry demands, yet it cannot be accessed on a scale to realise its benefits. The inability of business and researchers to engage and exploit key research capabilities in research institutions has emerged as a fundamental driver of the levels of R&D infrastructure use in South Australia.

Investment in research infrastructure determines the direction and scale of investment in R&D. Further, the nature, usefulness and conditions to access the research infrastructure will determine use of the infrastructure. In Chapter 7, the Commission will elaborate on a recommendation to maximise the net benefits from the state's investment research infrastructure.

5.2 Funding

5.2.1 Introduction

The nature of R&D and its financing means that it can be susceptible to market failures, resulting in an underinvestment in R&D from a society's perspective. These market failures relate to the uncertainty of outcomes, costs and returns, difficulties that researchers face in capturing the benefits of their research and asymmetric information and moral hazard in the relationships between lenders, equity investors and borrowers[52].

5.2.2 Business

There are several firm-specific factors which influence the extent of a 'financing gap'. These include location, sector of activity, firm size and firm age[53]. Younger and smaller firms are more likely to have challenges in securing the long-term loans required to finance R&D as they are typically characterised by lower levels of equity funding[54].

As noted in section 3.1.4 approximately 95 per cent of business expenditure on R&D in Australia is funded from a company's own funds. Therefore, a firm's ability to access finance is likely to be a key constraint to R&D activity in Australia.

Direct Government Support

Both the Australian and South Australian Governments offer grant programs to support businesses to conduct R&D. While these grants make up a very small proportion of total expenditure on R&D, there is international evidence that grant funding can have a significant effect on measures of financial, innovative and commercial success, especially for small and financially constrained businesses.

The South Australian Government primarily provides direct support for businesses through a range of grant and loan funding programs managed by the Department for Innovation and Skills. These include the Research Commercialisation and Startup Fund, the Medical Devices Partnering Program (MDPP) and the Photonics Catalyst Program. Further funding programs are available through other agencies including Defence SA. They tend to be smaller in scale and more targeted to specific areas of government priorities.

[52] Bronwyn H Hall. and J Lerner J, 'The Financing of R&D and Innovation', in Bronwyn Hall and Nathan Rosenberg (eds.), Handbook of the Economics of Innovation (North Holland, 2010).
[53] P Moncada-Paternò-Castello. et. al., Financing R&D and Innovation for Corporate Growth: What new evidence should policymakers know? (Policy Brief, European Commission, 2014).
[54] T FCooley and VQuadrini 'Financial Markets and Firm Dynamics', (2001) 91 American Economic Review,1286-1310.

Stakeholders support these programs, noting the levels of funding available are modest compared to Australian Government programs.

Stakeholders also considered that the South Australian Government has preferred to invest in physical infrastructure and other projects with a more immediate economic impact rather than R&D projects.

> *In recent years, budget pressures have meant the South Australia Government has favoured physical infrastructure (preferably 'shovel ready') projects and investment in training, entrepreneurship and start-ups over investments in R&D. (Flinders University, DR4, p.9)*

Venture Capital

The Commission heard that one of the key issues in translating the state's R&D into productivity and economic growth is a difficulty obtaining funding to develop commercial products from the discoveries of basic research. This gap is commonly referred in R&D literature to the 'valley of death' as companies face significant costs in developing and validating a viable product while relying on existing capital as they are not yet able to generate revenue. This stage of the R&D has at least three key risks:

- technical (will it work beyond small scale?);
- commercial (customer, cost and value); and
- managerial (can the proponent grow a startup business?).

Venture capital is frequently the only external source of funding available to companies to bridge this gap as it is beyond the scope of existing R&D support programs, and the risks of the enterprise are significantly higher than traditional finance sources are prepared to bear.

South Australian firms have historically received little venture capital compared to the larger states. In 2018-19, approximately 1.1 per cent of new and follow-on venture capital and later stage private equity funding occurred in South Australia[55].

To address the lack of venture capital in South Australian and to help build South Australian companies to a national and global scale, the South Australian Government established the $50 million SA Venture Capital Fund (SAVCF) in 2017. The SAVCF has been structured as a co-investment fund, requiring each initial investment into an eligible company to be matched with at least 50 per cent investment from other venture capital funds. Companies are required to have at least 50 per cent of their assets and 50 per cent of their staff located in South Australia for 12 months commencing on the initial investment date.

The SAVCF does not have a specific R&D innovation focus. Its remit is companies with export and growth potential that have a demonstrated market for their product or service.[56]

The Commission has heard from some businesses that the requirements to demonstrate a market for their product makes it difficult for companies generated from university R&D to obtain funding.

The SAVCF advised the Commission that since its establishment in 2017 the fund had met with 472 applicants with only four becoming successful. The low number, in the current fund manager's opinion, may have reflected the business model of the previous fund manager, which was to generate income for the government and required businesses to prove they

[55] ABS 5678.0 – Venture Capital and Later Stage Private Equity, Australia.
[56] <https://www.savcfund.com/>

could generate commercial returns. This model has since been reviewed. As of May 2020, 46 new opportunities had been assessed with one gaining approval.

5.2.3 Higher education

Generally, stakeholders expressed the view that South Australia's ability to attract R&D funding nationally is largely limited by its population size, with industry structure and a lack of significant R&D funding companies also being constraints.

> *South Australia's ability to gain R&D funding nationally may be limited by its population size and lack of critical mass, along with the relative paucity of major industries that provide R&D funding. (University of Adelaide DR9, p.10)*

For Australian Government grant funding, applications are typically assessed on:

- quality and track record of the researchers (including level of collaboration and overall strength and relevance of the research team to the proposed research);
- project proposal quality and innovation;
- feasibility;
- alignment with funding priorities;
- benefit; and
- institutional or partner support.

The Commission heard that one of the major factors influencing the number of competitive grants received in South Australia is the calibre and reputation of researchers.

> *South Australia success rates in attracting funding and investment in research are influenced by the calibre of the researchers, the strength of our collaborations and the facilities to undertake projects. Therefore, it is critical to attract and retain world class researchers within South Australia and to promote successful collaboration within the state, nationally and globally. A senior internationally renowned researcher will attract talented students to graduate programs, attract research funding from sources outside of the state, foster international collaborations and contribute to publications in international peer-reviewed journals. (Flinders University, DR4, p.12)*

All South Australian universities sought state government support to attract senior internationally renowned researchers, arguing that 'South Australia is often at a disadvantage in retaining and attracting researchers due to a lack of critical mass, a lack of capacity to invest collaboratively in people and infrastructure (new buildings notwithstanding), and a lack of niche research areas having demonstrated leadership'[57].

The Commission also heard assertions that assessors at funding bodies sometimes make judgements based on perceptions of the university.

> *It should be noted that as a smaller institution, Flinders University is frequently marked lower on 'research environment' in competitive grants, irrespective of, for example, the ERA ratings for a particular area of research or the level of research infrastructure we have to support it. (Flinders University, response to information request, p.12)*

[57] University of Adelaide, response to information request p.12

The University of Adelaide considered that in order to maintain success rates despite a significant increase in applications, funding agencies choose to only partially fund some successful grants or have the scope of the research scaled back.

> *The larger national research funding agencies are under considerable pressure to maintain their application success rates in the face of limited growth in their funding base and rapid growth in research application numbers. The result is often to fund research grant applications only partially. While the scope of the research can usually be reduced, the most problematic outcome is where there are salary shortfalls. (University of Adelaide, DR9, p.11)*

Funding for indirect costs

The Research Block Grants support the indirect costs of research, research training and collaboration efforts. They are allocated on a calendar year basis using program-specific formulae that reward the performance of providers in attracting research income and the successful completion of Higher Degree by Research students. In essence, the amount South Australian universities receive through block grants reflects their performance in attracting other research funding and PhD students.

The block grants are based on the amount of other funding the universities have earned. The allocation process for block grants does not take into account that the indirect costs of research projects may vary substantially. This includes both across and within fields of research. As a result, the block grants may be 'a mixture of subsidy and bounty' depending on the degree to which a project is funded[58].

Universities consider these grants are insufficient to cover the indirect costs of research.

> *Federal Government research and development funding schemes should provide the full costs of undertaking research, rather than be 'grants in aid'. Research Block Grant funding remains insufficient to cover the full indirect costs of research funded by schemes on the Australian Competitive Research Grants Register. (University of Adelaide, DR9, p.11)*

General University Funding

South Australian universities fund nearly half of their R&D (42.9 per cent) from general university funds. The largest source is surplus revenue from teaching. This includes domestic students, where it has been estimated that the cost of teaching was only 85 per cent of the Commonwealth supported place[59], and international students, from whom revenue far exceeds the Commonwealth supported place. One recent estimate suggests that 27 per cent of national university research is funded by international student fees[60].

This source of revenue, especially from international students, carries very significant risks to South Australia's R&D expenditure. As a result of border closures and social distancing requirements, Universities Australia estimates that Australia's universities could lose between $3.1 and $4.8 billion in revenue for the remainder of 2020 and up to $16 billion

[58] R Williams, 'Evaluating the Contribution of Higher Education to Australia's Research Performance', (2016) 49(2) The Australian Economic Review, 174-83.
[59] Deloitte Access Economics, Cost of Delivery of Higher Education (2016), Final Report, p. xxii
[60] A Norton, How reliant is Australian university research on international student profits?, (2020), Blog post, <https://andrewnorton.net.au/2020/05/21/how-reliant-is-australian-university-research-on-international-student-profits/>

between 2020 and 2023[61]. Consequently, Universities Australia further estimates that between $3.3 billion and $3.5 billion of university R&D activity annually could be at risk[62].

The Commission understands that a significant loss of university revenue from student income could be expected to adversely affect the amount of other research funding that requires co-investment, such as the Medical Research Future Fund; or reduce a university's ability to collaborate with industry, such as investing in CRCs. In addition, reduced university income may impact existing research and research funded through competitive grants as universities may not be able to cover the indirect costs associated with that research.

5.2.4 Conclusions

South Australia's universities have become reliant on sources of funding other than competitive grants to fund their R&D. This is consistent with other states, as the quantum of competitive grants available has not increased at the same rate as other sources of revenue and, moreover, did not cover the full cost of research. The reliance on international student fees to fund research has serious implications for continuity of effort within universities.

South Australian universities also have a below average success rate in applying for competitive grants through the ARC. Stakeholders suggested that South Australian universities' ability to attract funding, including through competitive grants, is limited by its population size and lack of critical mass, along with relatively few major industries that provide R&D funding. In addition, as discussed in Chapter 4, it is possible that the South Australia universities lack the type of research leaders that can organise and win bids for larger grants. As such, the potential for growth in competitive grants will be limited by these factors. The Commission makes recommendations to address these issues in Chapter 7.

5.3 Improving access to SA Government data

For most fields of research, data is a critical resource. Governments play a part in setting access rules and specifically access to the data they collect for their own purposes.

5.3.1 Government data

The large volume of data held by the Australian Government and its state and territory counterparts is regarded as an underutilised and valuable national resource[63]. Sophisticated use of data for public policy can underpin research to innovate and improve public services. Similarly, there are opportunities for commercial businesses to produce innovative services and products using such information, such as public transport scheduling and weather services to name just two.

In South Australia, researchers' access to data is governed by a complex regulatory framework. This includes the *Public Sector (Data Sharing) Act 2016* (Data Sharing Act), and the *Information Privacy Principles* (IPPs).

The IPPs are effectively a Cabinet directive, mandating use by all public sector agencies. The IPPs are outlined in *Premier and Cabinet Circular 12* (PC 12), which also establishes the South Australian Privacy Committee (the Privacy Committee) and specifies its membership,

[61] Universities Australia, Covid-19 to Cost Universities $16 Billion by 2023, (2020), Media Release, <https://www.universitiesaustralia.edu.au/media-item/covid-19-to-cost-universities-16-billion-by-2023/>
[62] Ibid.
[63] See, for example, the Australian Government's Public Data Policy Statement, <https://www.pmc.gov.au/sites/default/files/publications/aust_govt_public_data_policy_statement_1.pdf>

functions and powers. The Privacy Committee, among other roles, advises the minister on the desirability of legislation or additional administrative action and authorises exemptions from the IPPs on the basis of 'such conditions as the Committee thinks fit'[64].

Despite their importance for the management of data access in the public sector, the IPPs create a purely administrative framework regulating public sector agencies. Their provisions are not legally enforceable. The only legally binding requirements that apply to public sector data arise from the interplay of a variety of statutes, almost all of which are at the state level.

In addition to these state-based statutes, the Commonwealth *Privacy Act 1988* (Privacy Act) generally applies to Australian Government agencies and broad sections of the private sector, but can apply, under specified circumstances, to state and territory agencies, authorities and crown instrumentalities.

South Australia recently changed the way in which its public sector data is managed and used. The *Public Sector (Data Sharing) Act 2016* (SA) provides a statutory foundation for the management of data held by public sector agencies and aims to ensure that data is used appropriately as a resource to inform policy making and service delivery[65].

The Open Data Framework applies to South Australian Government public authorities, which include public sector agencies and administrative units as well as local governments. They are expected to develop open data strategies that detail specific actions and report on their progress. Public sector agencies are required to commit to maintaining the highest standards of privacy, security and integrity with respect to data they hold. Each agency's chief executive is responsible for the implementation of the framework and is ultimately responsible for all data and datasets made public.

All data approved for public release is published on Data SA, the South Australian Government's open data directory. Data SA currently includes over 1500 datasets from over 70 government agencies and local governments[66].

Discussions with government agencies indicate the process for approving data for release in many agencies has in many cases been ad hoc. Much of the data currently available on Data SA is not a result of any systematic analysis of what data government possesses, which would be valuable to researchers. It includes data that is easily gathered, interpreted and published such as measures contained in annual reports and data that was repeatedly requested such as traffic data.

To meet the required standards for privacy, SA government policy requires that unit record level of data may not be published or shared with researchers and that a level of aggregation is required to maintain privacy. Also, material that might be commercial in confidence may not be released. In doing so, a level of meaning is sometimes lost which has implications for its usability for R&D purposes. In many cases unit records have notes and comments attached to assist in understanding, but by their nature these are costly to aggregate.

The Commission considers this position needs to be tested to address the various competing public interests. Specifically, government might consider options to increase access to these unit records. Section 13 of the *Public Sector (Data Sharing) Act 2016* enables government to

[64] Department of the Premier and Cabinet (SA), PC 012 – Information Privacy Principles Instruction (2017), 3.
[65] See Public Sector (Data Sharing) Act 2016, particularly s 4(a-e), <*https://www.legislation.sa.gov.au/LZ/V/A/2016/PUBLIC%20SECTOR%20(DATA%20SHARING)%20ACT%202016_61/2016.61.UN.PDF*>.
[66] DPC, Open Data, (2020), <https://www.dpc.sa.gov.au/responsibilities/data-sharing/open-data>

enter into data sharing agreements with South Australia's three major universities. The Commission understands that this power has not yet been used.

Outside these formal agreements, researchers can request data from government. But there is no central point of contact in government for these requests, complicating the task of researchers and making it difficult to estimate the number of requests for data made each year. There are also no whole-of-government criteria or processes for providing data to researchers. Instead, the Commission has heard that decisions are made on an ad hoc basis with the outcome of a request differing by business unit.

Improvements to the process for publication of, or improved access to, state government data is one aspect within the state's control that could generate some benefits to South Australia's R&D sector.

There are options for improving use of unit record level data and meeting privacy requirements. One model is that used by the Australian Bureau of Statistics for sensitive data such as the Business Longitudinal Analysis Data Environment (BLADE). Research topics are approved by the ABS in advance and researchers use ABS facilities or virtual data labs to access the database. No data may be exported or released publicly without ABS approval to ensure privacy requirements and other legislative requirements are met.

Organising and publishing data for researchers outside of government may incur costs. It would be appropriate for government to investigate options for charging access to data, noting Australian jurisdictions take a range of approaches as exemplified in HMR.

Data linkage

Linking separate datasets can increase the value of data held by government. It involves identifying, matching and merging records that correspond with the same person or organisation from several datasets. As a result, this process faces additional challenges in ensuring that privacy is maintained.

SA NT Datalink was established in 2009 and provides a privacy protected record linkage process which enables previously unavailable data to be connected and made available for research purposes. The datasets managed by SA NT Datalink include a variety of health, education and social data. As such they are of highest value for health and medical and social sciences research. The Commission's inquiry into health and medical research noted that SA NT Datalink's ongoing funding arrangements are uncertain and recommended actions to ensure the ongoing operation of SA NT Datalink. This includes the development of a business model and business case for securing stable, multi-year funding.

The South Australian Government, in seeking to gain better insight into the state economy, has partnered with the Australian Bureau of Statistics to link state and Commonwealth data in a pilot project called the SA Business Longitudinal Data Integration Project[67]. The project seeks to use business datasets sourced from public administrative records to better understand aggregate employment and industry performance in South Australia. While access to the linked data has so far been limited to South Australian Government and ABS employees, there is potential for this to be expanded to other researchers.

Privacy legislation

Unlike most other states and territories, South Australia does not have legislation that specifically regulates privacy protection. The Commission's inquiry into health and medical

[67] < https://www.dpc.sa.gov.au/responsibilities/economic-insight-and-evaluation>

R&D has recommended the South Australian Government develop and enact information privacy legislation. While stakeholders haven't raised any specific concerns about the lack of specific privacy legislation outside of health and medical data, there is likely to be some benefit to other research sectors from specific privacy legislation that are worth further investigation.

Recommendation 5.2 Access to South Australian Government data

To enable South Australian researchers to benefit from access to South Australian public sector data and from inter-jurisdictional data linkage opportunities whilst ensuring robust privacy protections are guaranteed in statute, the Commission recommends that the South Australian Government develop and enact information privacy legislation that:

- complements the *Public Sector (Data Sharing) Act 2016*;
- streamlines and clarifies the current regulatory environment as it relates to the collection, storage, use and disclosure of public sector data in order to enhance access to it; and
- ensures that robust privacy protections are in place.

5.3.2 Other data

The Australian Research Data Commons (ARDC) was formed in July 2018 to enable the research community's access to nationally significant data intensive infrastructure platforms and collections of high-quality data. The ARDC builds on previous initiatives including the Australian National Data Service (ANDS), National eResearch Collaboration Tools and Resources (NeCTAR) and the Research Data Services (RDS). Currently, the University of Adelaide is the only South Australian member of the ARDC.

Barriers to access non-government data for R&D purposes may include privacy, integrity and cost as well as a desire to protect and maintain intellectual property. The requirement and costs of data for R&D vary significantly across fields of research and sectors. The Commission heard that the costs of purchasing data can be high, with one company, formed out of a CRC, having annual data costs exceeding $400,000.

Stakeholders instanced the Australian Space Data Analytics Facility (ASDAF) at Western Australia's Pawsey Supercomputing Centre and the Capital Markets CRC in NSW (now Rozetta Institute) as examples of government reducing business data costs. The ASDAF's stated aims are to*:*

> *'increase the likelihood of commercialisation success by connecting and leveraging existing national and state-based computing and data resources and seeking to lower the cost and risk of exploratory and novel use of space data for organisations and researchers'*[68]*.*

The Rozetta Institute purchases data and offers subscription data packages to its member organisations.

Other than noting the potentially high cost of data, there are no significant stakeholder issues for access to research data that the Commission is aware of excluding those raised in the HMR Inquiry.

[68] <https://pawsey.org.au/new-wa-capability-to-lead-space-data-analysis/>

6. Factors affecting R&D performance: human capital

This chapter focuses on human capital issues affecting the state's R&D performance (as identified in the terms of reference). These factors are:

- the demography of the state and its influence on the research workforce;
- talent pools and the capacity to attract new talent into research; and
- the effectiveness of labour resources devoted to research in collaborating on R&D outcomes.

6.1 Talent, skills and demography

Section 6.1 analyses talent, skills and demography as drivers of R&D. The analysis focuses on that part of South Australia's labour force devoted to R&D, its characteristics and the comparative size and characteristics of the R&D workforce in relation to other jurisdictions. The section makes conclusions about the importance of researchers in the state and the support government can offer in terms of research careers and post-research employment.

6.1.1 Introduction

The skill and demographic factors that support better R&D are a sufficient supply of highly trained, productive and qualified graduates and researchers, and clear pathways for career progression, as well as clear communication channels and linkages that promote effective diffusion of knowledge across the economy[69].

The South Australian Chief Scientist advised the Commission that:

- while Australia was ranked 15th out of 30 OECD countries for the total number of R&D personnel per 1,000 people employed, it was ranked 8th in its contribution to the top 1 per cent of highly cited research publications per million population.
- Australia has 8.2 doctorates per 1000 people of working age and ranks 11th within the OECD on this measure but below the top 5 performers (average of 16.8 doctorates per 1000 people).
- over half of researchers in Australia work in higher education with only one third employed in business. This contrasts with countries such as Israel and Canada where 80 per cent and 60 per cent respectively are employed in the business sector.

Recent years have seen the rise of educational and professional programs, including coursework, that are less 'traditional' in structure and can be tailored to external needs through modular offerings, particularly at the research and coursework master's degree level. These trends may have broader future appeal for industry in upskilling their workforce.

While the capabilities of the domestic workforce have a significant influence on R&D outcomes and are a source of growth for the stock of knowledge in the state, a 2006

[69] Department of Innovation, Industry, Science and Research, Research Skills for an Innovative Future: A research workforce strategy to cover the decade 2020 and beyond, Australian Government report (2011).

Australian Productivity Commission staff paper found the effects of R&D performed overseas were also positive and economically significant for Australia[70].

6.1.2 Stakeholder feedback

Business stakeholders have observed that South Australia has in most cases an adequate level of talent for their current level of BERD activity and that their experience has been more positive in recruiting and developing local graduates than in attracting experienced workers located in or outside of South Australia.

Public universities considered that the highly competitive nature of world-class research has meant South Australia is often at a disadvantage in retaining and attracting new and innovative researchers. Their explanations include a lack of critical mass of industry and financial resources, a lack of capacity to invest collaboratively in people and infrastructure (new buildings notwithstanding), and a lack of demonstrated leadership. This is in the context of some examples of specialised, world class research areas such as at the Australian Institute for Machine Learning (AIML).

Public universities also told the Commission that the perception of limited employment opportunities and the 'penalty' of receiving a low pay rate for three to four years during studies, are major disincentives to a student contemplating undertaking a research degree. As a result, there is a declining rate of enrolment of domestic students in research degrees.

Anecdotal evidence from Flinders University indicates increased difficulty in attracting high-quality postgraduate students despite the availability of scholarships; this is due in part to the attractions of highly ranked eastern state universities and high-salary jobs available there in many specialist fields like computer-modelling and artificial intelligence.

6.1.3 South Australia's demographic trends

The R&D performance of South Australia's labour force needs to be considered in the context of the state's demography. The number of people and their age are the predominant demographic influences on the supply of workers and their productivity. In summary:

- South Australia has the nation's second lowest population growth. The biggest factors contributing to South Australia's population growth and the differences in age structure are lower fertility rates and net interstate migration outflows.
- net interstate migration outflows have been continuous for South Australia since the late 1960s. During the period 1989 to 2019, approximately 105,000 people departed the state in net terms, reducing the potential population increase by one third.
- the 20 to 29-year age group accounted for 45.7 per cent of net interstate migration outflows between 1997 and 2019. This cohort is significant in terms of attaining higher levels of education, the supply of entrants to the workforce and labour productivity.
- net outflows of population interstate skew heavily towards professional occupations including many STEMM-related and research positions in business, government and research institutions.
- the effect of a disproportionately large number of professional workers departing the state, over such a long period of time, has significant impact on the age structure and

[70] Sid Shanks and Simon Zhang, Econometric Modelling of R&D and Australia's Productivity, Australian Productivity Commission, Staff Research Paper (2006).

productivity of the workforce, as well as the availability of skills for industry and research institutions to draw on. The 30 to 39-year age group accounted for 24 per cent of net interstate migration outflows between 1997 and 2019, some 19,500 people in the period of available data.

Having a smaller proportion of the 30 to 39-year age group, other things being constant, means reduced future entrepreneurship, leading to lower rates of business formation. The presence of both peer effects (the number of age peers positively influences the information and resources available to entrepreneurs) and the 'rank effect' will add to the decline in entrepreneurship rates (older individuals remaining in the workforce reduce the opportunity for younger workers to gain skills and capabilities through occupational advancement)[71].

Data on business formation and exit from June 2019 suggest South Australia has a relatively static business sector. South Australia's share of new business entries is well below its population share across all the firm size categories, with the relative weakness being particularly apparent amongst firms with employment over 200 FTE, where it only accounts for 3 per cent of new entries[72].

6.1.4 Educational Attainment

Table 6.1 indicates that compared with NSW, Victoria and Australia, the educational attainment of SA employed persons is strongly under-represented in higher education (degrees and above) and is over-represented in other categories.

Table 6.1: Distribution of educational attainment of the employed at February 2020 (%)

	Degree & above	Diploma or certificate	Year 12	Below Year 12	Total
NSW	39.2	29.5	16.9	14.4	100.0
Vic	40.0	29.5	16.9	13.6	100.0
Qld	29.7	34.0	20.2	16.2	100.0
SA	28.8	32.3	20.5	18.4	100.0
WA	32.2	32.8	19.1	16.0	100.0
Tas	29.6	34.2	14.1	22.1	100.0
NT	29.9	32.8	16.0	21.3	100.0
ACT	47.9	21.4	21.7	9.0	100.0
Australia	36.0	30.9	18.0	15.1	100.0

Source: ABS Catalogue No. 6291.0.55.003, Labour Force, Australia, Detailed, Quarterly, February 2020, Table 24a

Growth rates in educational attainment of persons employed over the last four years indicate that SA has seen the strongest growth in the Year 12 qualification cohort. As indicated in Table 6.2 the growth rate of 2 per cent in the higher education cohort is below the national average of 5.3 per cent per year. This may imply that SA is not producing enough graduates. Another possible inference may be that the SA economy does not generate enough of the right jobs to employ the supply of graduates.

[71] Russell.S Sobel, 'The Effect of Demographic Trends on Entrepreneurship Rates: Theory and Evidence' in Steven Globerman and Jason Clemens eds, Demographics and Entrepreneurship: Mitigating the Effects of an Aging Population (Fraser Institute, 2018).
[72] ABS, Counts of Australian Businesses, including Entries and Exits, June 2015 to June 2019. Cat. No. 8165.0

Table 6.2: Growth rate in educational attainment of the employed between Feb 2016 and Feb 2020 (% per year)

	Degree & above	Diploma or certificate	Year 12	Below year 12
NSW	4.8	1.2	1.6	-1.4
Victoria	7.1	1.5	1.6	-2.3
Queensland	6.0	0.5	1.0	-0.8
SA	2.0	1.0	4.0	-0.3
WA	2.9	1.0	3.0	-3.1
Tasmania	7.6	-0.1	3.8	-0.3
NT	4.4	-1.0	-2.1	-0.1
ACT	4.4	-0.2	4.7	2.1
Australia	5.3	1.0	1.9	-1.5

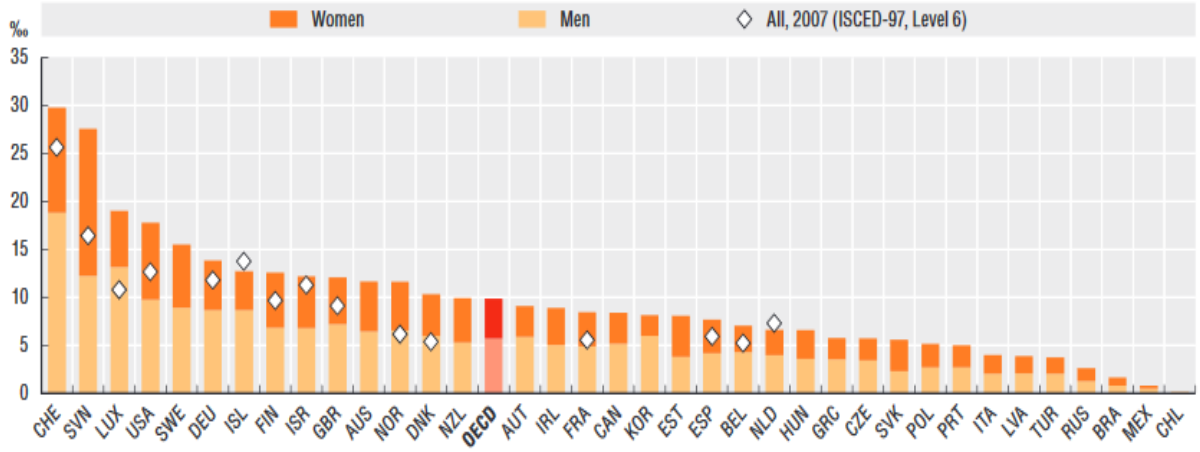
Source: ABS Catalogue No. 6291.0.55.003, Labour Force, Australia, Detailed, Quarterly, February 2020, Table 24a

6.1.5 The R&D workforce

Measuring the R&D workforce for South Australia is challenging. While the ABS and universities publish staff numbers and a full-time equivalent measure of time devoted to R&D, there is little clarity around who outside of universities is conducting R&D and where.

Some proxies of the R&D workforce include staff with a research degree, although there is typically only data on Doctors of Philosophy (PhDs) as there is no distinction in reporting between coursework and research master's degrees. This measure is also problematic as there are many PhD qualified employees not employed in a R&D role and many staff active in R&D who are unlikely to have a PhD.

Figure 6.1: Doctorate holders per thousand population aged 25-64, by country, 2016



Source: OECD[73]

In 2016, Australia had a slightly higher proportion of PhD holders in the working age population than the OECD average, as shown in Figure 6.1.

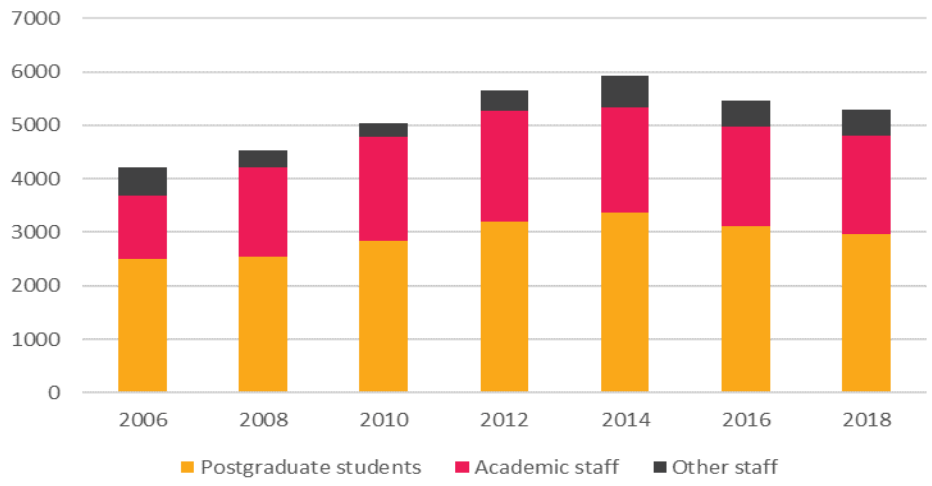
[73] OECD, OECD Science, Technology and Industry Scoreboard 2017: The Digital Transformation (OECD Publishing Paris, 2017).

OECD data suggests that approximately 46 per cent of researchers in Australia were employed in the higher education sector in 2016[74]. A further 42 per cent were employed in the business sector, with 8.6 per cent in the government sector and the remaining 3.6 per cent in private non-profit organisations.

Higher education

Over the 10 years to 2018, the total number of person years of effort (PYE) devoted to R&D has risen by an average of 1.6 per cent per year. Figure 6.2 shows this growth is largely a result of increases in postgraduate students and other staff. The number of academic staff (PYE) in 2018 was only 9.5 per cent higher than 2008 and total human resources devoted to R&D has fallen since 2014.

Figure 6.2: Higher education human resources devoted to R&D, PYE, by type, South Australia



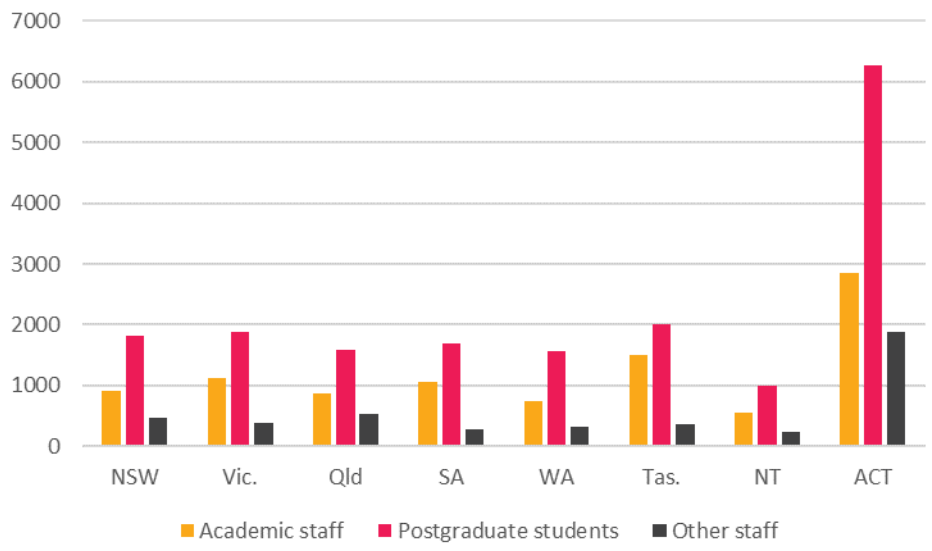
Source: ABS 8111.0

Measures of R&D workforce intensity

In the context of the R&D workforce, measures of intensity include number of researchers per 1 million population, or per working age population.

[74] OECD.Stat, R&D personnel by sector and function (2020) <https://stats.oecd.org/Index.aspx?DataSetCode=PERS_FUNC> Note: for the business sector data is not available for 2016 so the average of 2015 and 2017 has been used instead.

Figure 6.3: Academic staff devoted to R&D (PYE) per 1 million population, by location, 2018



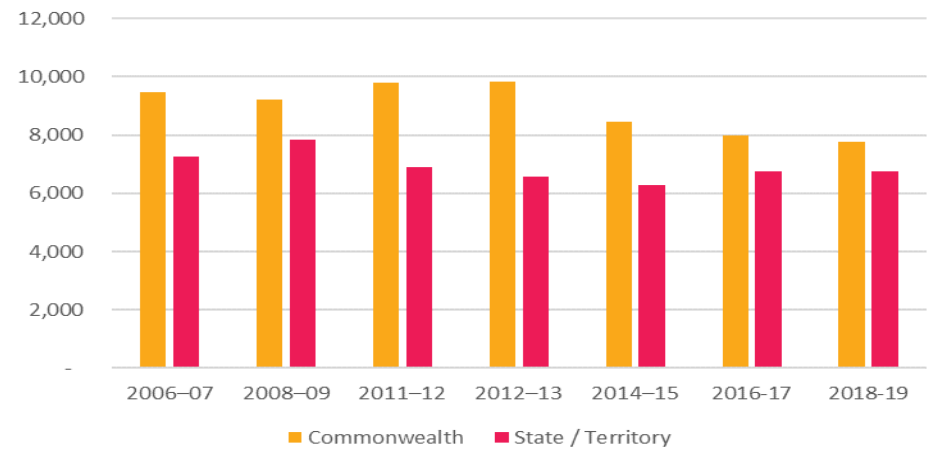
Source: ABS 8111.0, ABS 3101.0

In terms of number of academic staff per million population (Figure 6.3), South Australia has the fourth highest number (1,063), behind the ACT, Tasmania and Victoria, and fifth highest number of postgraduate students (1,702). South Australia also has the second lowest number of other staff devoted to R&D, above only the Northern Territory.

Government

The ABS publishes estimates of human resources devoted to R&D nationally for the Australian Government and all state and territory governments, but this data is not disaggregated to individual state and territory governments. Figure 6.4 shows that in 2018-19, there were 7,763 Australian Government employees (PYE) and 6,758 state and territory government employees (PYE) devoted to R&D across Australia.

Figure 6.4: Government human resources devoted to R&D, PYE, Australia, 2006-07 to 2018-19



Source: ABS 8109.0

Nationally, there has been a decline in the number of staff dedicated to R&D in both federal and state governments since 2006-07.

The Commission has not identified any data on the size of the research workforce within various functions of government. However, an analysis of LinkedIn data reveals that hospitals and health care are the largest employer of PhD graduates in the government and non-profit sector, followed by state governments and the federal government.[75]

Business

In Australia, the total number of business R&D FTE personnel per thousand employees was 9.4 in 2013, compared to 9.8 across the OECD, and the average of the top five OECD countries of 19.2[76].

Australia also has a lower proportion of total researchers in the industry sector (43 per cent compared to an OECD average of 48 per cent). The OECD also estimates that 44 per cent of researchers in Australia are employed in the higher education sector. However, the state's lower levels of business expenditure on R&D mean this is unlikely.

An analysis of PhD employment using LinkedIn data shows that over 70 per cent of PhD graduates employed in the private sector in Australia work for companies with over 500 employees[77]. These employees were most likely to be employed in the banking, financial services and insurance industry, followed by mining, oil and energy, medical and pharmaceutical and civil engineering.

6.1.6 Research workforce findings

The Commission's analysis concentrates on the size, profile and skill base of the state's research labour force in supporting businesses and research institutions to undertake R&D in the state. In addition, the influence of workforce supply, educational outcomes and demographics on the state's research workforce is examined.

It is first useful to distinguish between the STEMM and the research workforce. The STEMM workforce, comprising mainly professionals, technicians and some managers, relates to that part of the workforce undertaking science and innovation, including R&D.

The STEMM workforce represents the portion of the workforce employed in science, innovation, technological, research and medical occupations. The STEMM workforce is integral to high-value industries and growth sectors and has skills widely desired by the business sector.

The research workforce is a subset of the STEMM workforce. The research workforce refers to those workers directly undertaking R&D as well as workers external to the R&D unit contributing to the output. From a functional perspective, the research workforce comprises

[75] P McCarthy and M Wienk, Advancing Australia's Knowledge Economy: Who are the top PhD employers? (AMSI, 2019) 9, <https://amsi.org.au/wp-content/uploads/2019/04/advancing_australias_knowledge_economy.pdf>

[76] Department of Industry, Innovation and Science, Australian Innovation System Report, (2016), Chapter 4, <https://www.industry.gov.au/sites/default/files/May%202018/document/extra/australian_innovation_system_report_2016_-_Chapter_4.pdf?acsf_files_redirect> p.64.

[77] P McCarthy and M Wienk, Advancing Australia's Knowledge Economy: Who are the top PhD employers? (AMSI, 2019) 9,

researchers, technicians and other support staff (such as administrators, clerical workers and craftspeople)[78].

The STEMM workforce

Using an occupation list published on the Australian Government Labour Market Information Portal[79], the Commission has quantified the extent of the STEMM workforce in South Australia compared to the rest of Australia.

Table 6.3 presents the extent of the STEMM workforce in South Australia. Most of the STEMM workforce (over two thirds) have medical and engineering occupations with science, agriculture and environment occupations being the smaller component of the workforce.

In comparison to the rest of Australia, South Australia's STEMM workforce has a higher proportion of medical occupations (38.6 per cent compared to 30.9 per cent) and a lower proportion of IT occupations (12.9 per cent compared to 17.8 per cent).

Table 6.3: STEMM workforce by category of occupation, SA and the rest of Australia, 2018.

Category	SA No.	%	Rest of Australia No.	%
Science, agriculture and environment	8,753	5.7	122,067	5.2
Maths	20,369	13.2	381,364	16.3
IT	19,932	12.9	416,691	17.8
Engineering	45,699	29.6	697,548	29.8
Medical	59,630	38.6	721,915	30.9
Total	154,382	100.0	2,339,585	100.0

Source: SAPC calculations based on Training and Skills Commission of SA data

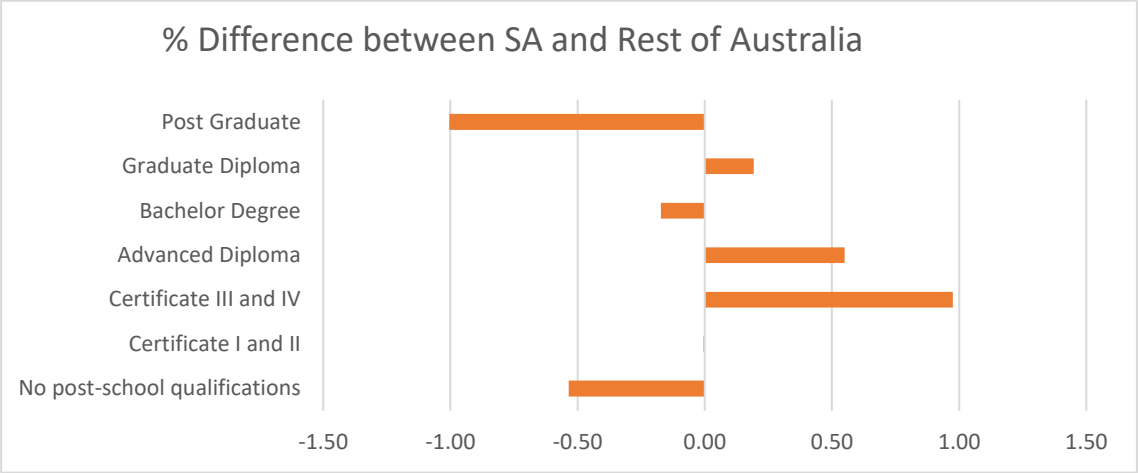
Note: Totals may not correspond due to rounding

Figure 6.5 depicts the skill profile of the state's STEMM workforce in comparison to the rest of Australia. South Australia has a lower proportion of people holding a postgraduate qualification and working in a STEMM occupation. South Australia has a slightly higher proportion than the rest of Australia in graduate diploma, advanced diploma and certificate attainment levels.

[78] OECD, Frascati Manual 2015: Guidelines for Collecting and Reporting Data on Research and Experimental Development, The Measurement of Scientific, Technological and Innovation Activities (OECD Publishing, Paris 2015), 161

[79] Labour Market Portal <https://lmip.gov.au/default.aspx?LMIP/GainInsights/SpecialTopicReports> Accessed 16/06/2020

Figure 6.5: Percentage difference between SA and the rest of Australia in composition of STEMM workforce, 2018



Source: SAPC calculations based on Training and Skills Commission of SA data

Research workforce sources of supply

Postgraduate students contributed 55.8 per cent of the state's R&D person years of effort in 2018 in the higher education sector. Postgraduate student numbers are important for the state's university sector to leverage competitive R&D funding. Further, a pipeline of postgraduate students sustains R&D activities inside universities.

Table 6.4 shows that between 2009 and 2018, South Australia produced 6,900 postgraduate researchers, equating to 7.4 per cent of the national total. The main fields of research for postgraduate research completions were health, society and culture, natural and physical sciences and engineering and related technologies. Compared to the rest of Australia, South Australia is under-represented in natural and physical sciences and over-represented in health. These statistics are for completions only and do not reveal where in Australia postgraduate researchers entered the labour market.

Table 6.4: Postgraduate research completions by field of research, all students, 2009-18, SA and rest of Australia.

Field of research	SA	Rest of Australia	SA as % of Australia	SA - Field as % of Total	Rest of Aus. - Field as % of Total
Natural and Physical Sciences	1,365	19,169	6.6	19.8	22.1
Information Technology	259	3,285	7.3	3.7	3.8
Engineering and Related Technologies	914	12,490	6.8	13.2	14.4
Architecture and Building	83	1,196	6.5	1.2	1.4
Agriculture, Environmental and Related Studies	477	3,884	10.9	6.9	4.5
Health	1,455	12,320	10.6	21.1	14.2
Education	261	5,357	4.6	3.8	6.2
Management and Commerce	446	5,947	7.0	6.5	6.9
Society and Culture	1,377	17,949	7.1	19.9	20.7
Creative Arts	272	5,201	5.0	3.9	6.0
Total	**6,909**	**86,798**	**7.4**	**100.0**	**100.0**

Source: U-cube – Higher education data cube https://www.education.gov.au/ucube-higher-education-data-cube

Academic workforce and postgraduate tertiary careers

The calibre of university researchers has an influence on attracting funding, leveraging resources for research purposes, drawing graduate students to research programs, fostering collaboration and contributing to academic publications. There is intense global competition for high calibre academics to lead faculties, research centres or research programs of strategic interest to universities, which in turn improves promotion of the university globally.

A significant disincentive to the potential supply of postgraduate researchers to the tertiary workforce is higher starting salaries for top graduates in other industries. Based on data from graduate surveys, median salaries of research postgraduates of South Australian institutions are generally lower than research graduates from other Australian institutions (for those graduates included in the graduate outcomes survey)[80]. Median salaries for science and mathematics postgraduate researchers from South Australian institutions are comparable to postgraduate researchers in the rest of Australia.

Fellowships are a key mechanism for developing early to middle-career researchers. They are used globally in various forms to develop junior researchers, to deliver discrete projects, to contribute to societal and program outcomes and to enable further collaboration with industry or other academics based on research results.

Over the past decade South Australian researchers were awarded 6.7 per cent of ARC Future Fellowships, slightly less than South Australia's population share. The success rate for the Discovery Early Career Researcher Award was lower, at 5.6 per cent of national fellowships over the same period.

Business research workforce

The largest share of Australia's research workforce is concentrated in the higher education sector. This is also true for South Australia's research workforce, and contrasts with most OECD countries where the private sector is the greatest employer of researchers.

One implication is South Australia businesses compete for a smaller researcher talent pool. This is exacerbated by the volume of graduates who move interstate for their first full-time job, as discussed earlier in this chapter. The outflow of graduates is indicative of too few pathways for graduates to employment in their field of study in the state.

The Commission has gathered statistical evidence on the low labour mobility for Australian research workers who have tended to spend the bulk of their careers in either the public or private sectors, with little crossover or direct experience of the alternative. The lack of labour mobility in Australia diminishes opportunities for collaboration between different sectors and between researchers and industry as there are fewer opportunities for interaction between the two groups[81]. More mobility across and within sectors would help stakeholders recognise the value that each party can offer.

This is reinforced in the results of the Graduate Outcomes Surveys in 2018 and 2019[82]. Students were asked if they felt they had opportunities to develop contacts outside the

[80] Provided to the SAPC on request by Quality Indicators for Learning and Teaching. Data is sourced from both the Australian Graduate Survey (2012-2015) and the Graduate Outcomes Survey (2016-2019). Only fields of education with sufficient response size have been published. The data does not describe whether the salaries being earned are in occupations related to the graduate field of education.
[81] Australian Industry Group, Joining Forces: Innovation Success Through Partnerships, Research Report (September 2016).
[82] Provided to the SAPC on request by Quality Indicators for Learning and Teaching. Data is sourced from both the Australian Graduate Survey (2012-2015) and the Graduate Outcomes Survey (2016-2019).

university sector and whether they had opportunities to work on research problems with organisations outside the university sector.

At the national level, of the 21 fields of research for which the survey data is categorised, at least 1 in 3 students felt that they had not developed contacts outside the university sector and often the rates for each field of research were below 60 per cent of students developing contacts outside the sector.

In terms of working on problems with organisations outside the sector, the proportions are even lower at the national level. Students in most fields of research report rates of practical application of knowledge of less than 50 per cent. While the data is more volatile at state and territory level, the results in South Australia mirror that of Australia.

6.1.7 Conclusions

The Commission has not found any obvious barriers, regulatory or financial, that prevent mobility between sectors, suggesting the underlying factors may be cultural. In the university sector, they relate to the entry and nature of employment within the higher education sector, the sectoral focus on internal promotions and the ability of researchers to secure basic research funding to support ongoing positions. Within the business sector, the ability to implement flexible working arrangements and the highly specialised skills of researchers are factors.

These considerations suggest there is value in broader, earlier and deeper engagement between higher education and business to develop relevant industry skills in graduates by graduation. A possible mechanism for doing this in South Australia could be policies that specifically support the development of high-quality R&D talent by both the higher education and business sectors. The EXCITE strategy supports the realisation of these objectives, for example by making funding available for the development of Doctoral Training Centres. The Commission agrees that such a program will enable earlier and deeper engagement by postgraduates with industry.

The Commission can also see the benefits of a partnership between key industries, the universities and government to encourage recruitment of new students into areas of research that correspond to the state’s research strengths and those industries identified in the state government’s growth state agenda.

The Commission’s recommendations to address these issues are contained in Chapter 7.

Postgraduate employment

The factors that influence decisions on job locations are salaries, promotion prospects and career development as well as non-employment factors such as access to government services, living costs and levels of social interaction. In the case of research graduates, the chance to embed themselves in a meaningful and productive research community is a key consideration.

Universities compete to attract and retain graduate talent with startup packages and other incentives. The university sector in South Australia has the scope to address and enhance these aspects in its graduate recruitment process.

There is scope for the state government, as a major employer, to support more research skill positions with the public sector. There are agencies of government that do research as core activities such as SARDI, DEW, DEM and local health networks. These agencies have scope

to contribute to postgraduate employment and to provide pathways for career researchers through collaborative research projects with industry and academia.

Such a program however should only be considered with the necessary pathways to meaningful employment in private sector research activity in the long-term.

The Commission's recommendations to address these issues are contained in Chapter 7.

Academic workforce

In terms of academic workforce size and quality, funding schemes and postdoctoral initiatives can provide support and opportunities for researchers to collaborate and develop the research capacity required to attract future funding. Universities can support academic workforce development through postdoctoral and research fellowships fully funded by outside agencies such as the ARC or through mechanisms inclusive of matching funding from universities, as is the case with ARC Future Fellowships.

While universities have the greater interest in facilitating academic workforce outcomes, state governments have also contributed. The Veski Fellowship program by the Victorian Government is one such program[83]. Other policy levers identified by stakeholders include bridging scholarships for early career researchers to alleviate the problems associated with the long lead-in times of annual research grant processes.

The Advance Queensland Industry Research Fellowships program supports researchers partnering with industry to complete original research that will have a positive impact on Queensland. The program is focussed on establishing and/or maintaining meaningful collaboration between researchers and industry, offering:

- up to $180,000 over three years for early-career fellowships; and
- up to $300,000 over three years for mid-career fellowships.

Applicants are encouraged to align their bids to one of the Queensland Government's investment areas.

To support growth in this area, the state government could consider support for industrial PhD programs to ensure more engagement of HDR students with business throughout the time of earning their qualification. An example of this is the Danish industrial PhD program where a student is employed by a company and enrolled at a university. The student then divides their time between university and the company to work on a PhD industrial project with the salary drawn from a project fund.

The Commission's recommendations to address these issues are contained in Chapter 7.

6.2. Collaboration

6.2.1. Introduction

Universities Australia estimates that $10.6 billion in annual business revenue results directly from partnering with universities, contributing $19.4 billion annually to Australia's income, and adding 30,000 full-time positions nationally[84].

[83] See: <https://www.veski.org.au/fellowships>
[84] Universities Australia (Cth), Clever Collaborations: The Strong Business Case for Collaborating with Universities (2017).

However, survey evidence suggests that Australian innovation-active businesses report relatively low rates of collaboration on R&D. Over the past decade, around 5 per cent of Australia's innovation-active businesses collaborated on R&D, with annual variation.

By size, large innovation-active businesses reported the highest rates of joint R&D activity (8.9 per cent in 2017-18). This compares to only 6.4 and 3.5 per cent of innovation-active medium and small-sized businesses collaborating on R&D in the same period. By industry, the mining industry and professional, scientific and technical services reported the highest share of innovation-active businesses with joint R&D activities[85].

Data provided by the South Australian Office of the Chief Scientist indicates there is a significant performance gap both in Australia and in SA between the excellence of STEM research outputs and the level of industry research collaboration. Overall, excluding Earth Sciences, 60 per cent of STEM subfields in SA were placed as equivalent to performance in the bottom quartile of the OECD for industry-research collaboration[86].

Collaborations between the basic research sector and industry are in line with that of other states, but overall Australia is a poor performer, according to the OECD. In the period 2014-2018, there are almost no STEMM fields of research, based on the OECD sample, where SA ranks in the top quartile for industry collaboration and in fact, most fields of research rate in the third or fourth quartiles.

6.2.2. Models of collaboration

This section outlines the elements of successful collaboration mechanisms that may be relevant in South Australia.

Research undertaken by the Commission reveals that there is no typical collaboration model. According to the OECD[87], the variations across countries in policy choices and implementation reflect the characteristics of the country's business sector, including firm size, industry structure, technological capabilities and ownership.

The common thread of overseas collaboration models is public action to generate economic growth driven by 'additionality' which is usually geared towards societal problems, technical challenges and the extraction of value rather than focusing on business size or industry. Interventions are judged by commercial success and need to demonstrate that they add value over and above what would have occurred without support.

Some governments assist technology transfer offices of universities through finance for commercialisation, such as in the United Kingdom under University Challenge funding. By contrast, in the United States most funding comes from private sources encouraged by government through schemes such as the Small Business Innovation Research Program (SBIR) and the Small Business Technology Transfer Program (STTR).

A caveat is that many of these models come from economies, regions or trading blocs that are very large, with large corporations and exceptional research institutions. Those conditions do not apply in South Australia and so the relevance of the models needs testing.

[85] Australian Bureau of Statistics Characteristics of Australian Business, Catalogue Nos. 8129.0, Cat. No. 8158.0, Cat. No. 8166.0, Cat. No. 8167.0
[86] OECD ranking of Australia for STEM fields of research and equivalent ranking of South Australia using measures of research performance and collaboration (2014-2018) using Incites Clarivate data.
[87] OECD, University-Industry Collaboration: New Evidence and Policy Options (OECD Publishing, Paris 2019).

Government roles in research institution and industry collaboration, apart from participation as a third party, are predominantly for:

- facilitating introductions for non-formal relationships and information sharing, and putting into place formal structures where relationships will be long-standing;
- providing incentives or complementary programs to facilitate the relationships or support elements of collaboration such as student placements;
- providing supporting infrastructure (such as incubation centres or innovation parks);
- providing innovation support services for enhancing commercialisation; and
- ensuring policy, legislation and regulation support and encourage collaboration.

6.2.3. Research institute and business collaboration outcomes

The assessment of outcomes of research and business collaboration occurs at the institutional, firm, industry and economy level. Many of the institutional benefits of collaboration can be described as tangible but difficult to quantify and have different effects and different meanings for each party involved.

Some of the more quantifiable benefits for universities include joint publications, acquisition of up-to-date equipment and development of spin-off companies. For firms, the benefits include the acceleration of commercialisation, hiring graduates and PhD students, joint publications and keeping up to date with and adopting new technologies.

State government program assessment

Chapter 2 of this report summarised state government R&D programs, both historic and current; this section concentrates on programs which focus on R&D collaboration. The state government has administered a number of programs aimed at influencing and promoting collaboration between business and researchers. The Commission has been provided with information about two programs, NanoConnect and the Premiers Research and Industry Fund (PRIF), under which a number of collaborative programs are administered.

The PRIF funded 13 research projects worth $1.65 million supporting critical industry sectors including agriculture, automotive, advanced manufacturing, mining, health, defence and data analytics.

The NanoConnect program was part of the Manufacturing Works strategy, implemented to support increased collaboration with researchers and the adoption of new technologies by manufacturers.

Outcomes of the NanoConnect Program included the establishment of a company based on the development of new materials and technology, and greater awareness by industry of nanotechnology and materials capabilities in South Australia. There were interactions with more than 100 South Australian businesses with 35 of these participating in workshops, 25 in nanotechnology reviews and 12 in feasibility studies to understand the application of nanotechnology in their business.

The SA Early Commercialisation Fund and Innovation Vouchers Program made 48 new investments worth $8.2 million in new technologies and intellectual property.

In the first three years of operation, the PRIF had invested $17.1 million in competitive grants. The program was found to have:

- leveraged $25 million in partner cash contributions, plus at least that amount of partner in-kind support, providing a total injection of almost $70 million into the state's research activities and economic development;
- established 10 fellowships for internationally acclaimed researchers;
- directly generated over 100 new jobs in South Australia, helped retain promising early-career researchers in the state and played a significant role in broader jobs creation through the additional research activity stimulated by the program; and
- led to around 60 partnerships with industry, as well as nearly 50 international collaborations spanning 19 countries.

A refocus of the program has since concentrated on larger projects to increase economic impact, directing funds to areas of highest priority, and greater integration of projects with other SA Government programs and initiatives.

To achieve sufficient scale of effort, research organisations and industry/end users were encouraged to collaborate in outcomes focused 'Challenges-Based Research Consortia' that offer the necessary multi-disciplinary expertise and funding leverage. As the research consortia program is still in operation, the full impact has not yet been assessed.

The South Australian government launched Go2Gov during 2020, a program designed for startup businesses to partner with government on projects and service delivery. The state government issues public sector challenges and invites and supports startups to submit proposals to address them.

University perspective

The three public universities have identified individual examples of collaboration excellence and success involving their organisation and key industries:

- The University of South Australia has had a long-standing success in multi-year, multi-company consortia via the brokerage of AMIRA global to deliver basic research outcomes and contract research outcomes for partners in the minerals and mining industry.
- With the assistance of the South Australian Government, the University of Adelaide has established the Adelaide Institute of Machine Learning a key research institute in machine learning globally. The institute is headquartered at Lot Fourteen and will enable collaboration with defence and space companies.
- The Australian Industrial Transformation Institute at Flinders (Tonsley) is working to facilitate knowledge and technology transfer between researchers and industry. With financial support from the Innovative Manufacturing CRC and BAE/ASC Shipbuilding, the project is accelerating uptake and diffusion of innovative manufacturing technologies in Australian shipbuilding and its supply chain and engaging directly with the prime company and its suppliers.

In terms of collaborations undertaken by the higher education sector across the range of commercialisation support, industry engagement and innovation organisations, outcome measures provided to the Commission by the universities are summarised here. Between 2013 and 2019 Flinders University has:

- trained more than 700 entrepreneurs and taught more than 2000 students;

- examined 500 ideas for medical devices and conducted 135 collaborative workshops and 90 R&D projects;
- created more than 300 startups; and
- earned $3.3 million in revenue through licensing arrangements.

The University of Adelaide enters into more than 450 research agreements each year which allow an industry partner to protect intellectual property and to commercialise research conducted during that project. The university generates approximately $5 million annually of royalty income from IP. In terms of patents and licences:

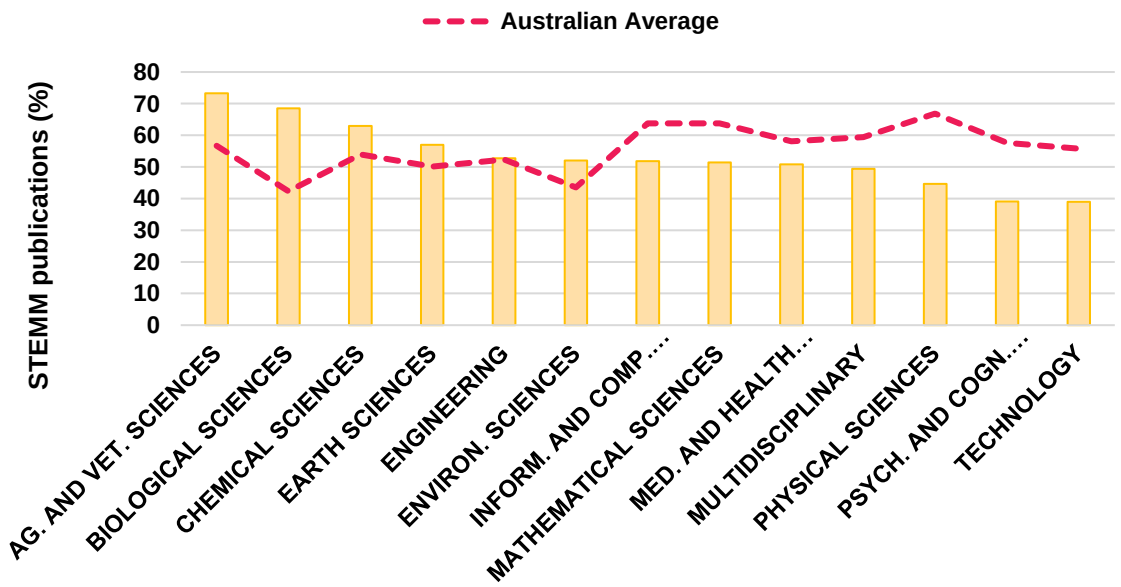
- 31 of 31 Plant Breeders Rights are licensed;
- 29 of 48 patents managed by the University have been licensed or are under option, with a further 2 used for leveraging grants;
- an additional 20 patents are managed by licensees; and
- not all licences have a patent associated with them. Of 117 active licences, approximately 50 do not have a patent associated with them.

Publications data: collaboration through co-authorship

The proportion of academic publications developed in cooperation with international academics or with an industry partner can provide an insight into the level of collaboration of institutions and jurisdictions. This measure does not consider quality of outputs, impact of research or dissemination into productive use. In addition, there is no control for effort intensities in fields of research or factors singular to industries or institutions.

Figure 6.6 indicates that South Australian researchers have higher than Australian average collaboration with international co-authors in a number of fields including agriculture, biological sciences, chemical sciences and earth sciences.

Figure 6.6: Proportion (%) of STEMM publications with international co-authors, SA, 2009-18

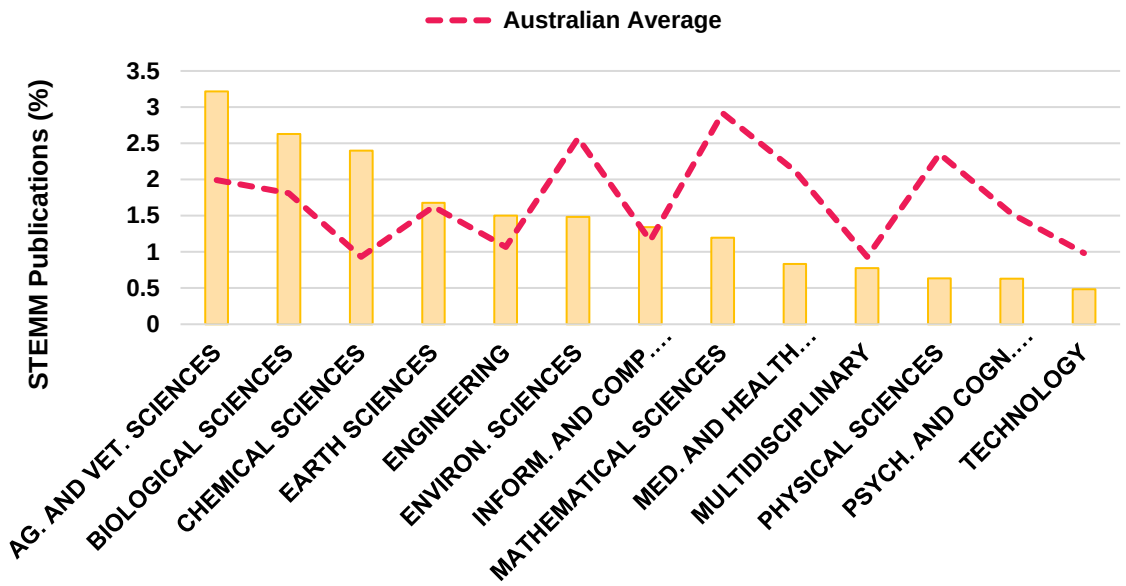


Source: South Australian Office of the Chief Scientist analysis of the Clarivate Analytics' Incites Journal Citation Reports system.

In terms of the proportion of STEMM publications with industry co-authors, Figure 6.7 shows that South Australian researchers again outperform the Australian average on agriculture, biological, chemical and earth sciences and engineering. This corresponds to the industry examples outlined in this section and indicates that South Australia's relative strengths on collaboration between industry and researchers currently resides in agriculture and the mining related disciplines in chemical and earth sciences and engineering.

Research collaboration is important as it facilitates the diffusion and exchange of knowledge, grows and exploits networks for knowledge exchange and promotes organised firm behaviour at an increasing scale.

Figure 6.7: Proportion (%) of STEMM publications with industry co-authors: SA 2009-2018



Source: South Australian Office of the Chief Scientist analysis of the Clarivate Analytics' Incites Journal Citation Reports system.

Industry assessment of outcomes – primary industries

Inquiry participants provided the Commission with a range of views and information regarding collaboration relating to primary industries.

The models of collaboration in the sector are based on broad participation, financial support levied for application to R&D, and with various governance models administered by statutory bodies, industry associations, state government or cooperatives. The priorities for research are usually agreed following a consultation process. There are varying standpoints on levels of success using various, mainly qualitative, measures.

The Crop Science Society of SA considered that the extension activities of key R&D outputs led to improved gross production and increased efficiency in highly competitive markets and changing environments.

Livestock SA considered the benefits from R&D arose from government, research and industry collaboration through the meat and sheep industry strategies (blueprints) for growth. The University of Adelaide's Davies Centre, TAFE SA, SARDI, PIRSA and other organisations have strengthened alliances to work together to ensure industry and regional

growth. The blueprints have attracted the development of funding and collaborative projects linked to the national Meat Industry and Sheep Industry Strategic Plans (MISP & SISP).

In the water industry, the Goyder Institute stated it has successfully fostered collaboration between researchers and end users. This is actively facilitated through a governance model which includes a management board, a research advisory committee, project advisory committees and project teams. Collectively, this governance achieved a highly cooperative approach to identifying water knowledge gaps, targeted research projects and direct adoption pathways. The model required the sponsored research to directly focus on specific water issues, as identified by Government and industry, by:

- establishing up-front priority knowledge requirements from end users;
- establishing multi-disciplinary and multi-organisational research teams that have the necessary skills to comprehensively cover the relevant research question; and
- enabling the ongoing involvement of end users in the research project process.

The Marine Fishers Association of South Australia provided input on the outcomes of research and development collaboration for their sector funded through contributions from industry. The association considered that in recent years, the funds set aside for R&D have not achieved benefits for the industry. The Association proposed greater collaboration on industry research priorities and increasing contestability by opening competitive tendering for research projects to private sector firms.

6.2.4. Stakeholder feedback

Feedback to the Commission indicated that collaboration between business and researchers can break down due to a lack of understanding of the other parties' needs, differing motivations and differing responses to incentives. Development of relationships between SMEs and universities requires different incentives and approach to the development of relationships between larger firms and universities. In the former, tax incentives and grants play a large role, and in the latter, investment attraction and market access are key.

The university sector considers research commercialisation benefits significantly from being co-located with the business, technical, and industrial operations of large, typically national or multinational companies. These firms provide a focus for identifying research priorities and engagement strategies.

Similarly, the rotation of key staff between research institutes and industry, facilitates researcher understanding of the needs of and issues facing industry.

Such interactions were observed by stakeholders only to occur at the informal level with research staff. The large number of small businesses in South Australia, in contrast to the size and remit of universities in producing commercialisation results, is seen by small business as a key barrier to better outcomes.

University experience points to few government programs that can bridge the gap successfully between researcher and businesses. The University of South Australia identified their Future Accelerator program as having successful enterprise engagement outcomes. Universities acknowledged the fundamental recent change in how they engage with industry in terms of their language and focus on practical outcomes for the business.

Consultation undertaken by the Office of the Chief Scientist for the development of the EXCITE plan indicated industries which had engaged with researchers with deep experience

in working with industry found their experience to be positive and productive. There were also reports of researchers being more interested in having funding for their work than delivering on the milestones agreed with the companies — a clash of cultures.

Another key observation made by small business is that collaborative and competitive forces can come into conflict in the marketplace often with self-interest of parties taking precedence. Examples provided to the Commission identify instances where commercial arms of universities or institutes of universities with the ability to spin-off companies or licences are in direct competition with small businesses. Instead of seeking university collaboration, the small businesses avoid interaction to avoid loss of opportunities or customers.

6.2.5. Findings

The experience in South Australia suggests that collaboration can lose traction and momentum over the long-term as other priorities emerge for all parties.

Knowledge Transfer

The evidence provided to the Commission indicates knowledge transfer is confined to a small number of mechanisms. There appears to be greater scope for collaboration activities of value beyond that which occurs currently, to meet societal problems and areas of technological challenge. There is considerable opportunity to orientate collaborative activities into areas of demand and areas of common interest between business and researchers.

Further, there is scope to increase the number and effectiveness of knowledge transfer mechanisms as well as address the gap in funding mechanisms that currently exists. The University of Adelaide refers to the previous Biotechnology SA model as an example of providing access to capital and commercialisation skills. The role and history of Biotechnology SA is discussed in more detail in Chapter 2. The BioSA model:

- enabled proof-of-concept funding for proponents, and opportunities to leverage university funding and funding from the business sector;
- created a pipeline of technologies available for commercialisation; and
- provided experienced staff to support networking and collaboration of investors, companies and researchers. Staff had the necessary experience, knowledge and familiarity with people in the industry and with those who could provide independent insight on projects.

While the BioSA model was applied to the health and medical sector, there is potential to apply it more broadly to other sectors. The absence of both intermediary, brokerage services and the expertise of sectoral representatives independent of researchers, investors and companies has been identified as an issue by a number of stakeholders.

The SA government recently committed $7 million to support external innovation and translation intermediaries to enhance industry-research collaboration. The intermediaries will operate within innovation districts through pilot programs. The initiative has two elements to assist in decision making and resource allocation:

- pre-condition qualifiers for the pilot program to establish external intermediaries. (The innovation district must be at the stage of maturity where investment in an external intermediary will deliver value and a return on investment); and
- a guide to establishing external intermediaries.

Cultural Issues

The Commission heard from stakeholders that the business and the research sectors have difficulty engaging with one another. In some respects, industry finds universities to be large, formidable organisations, in which it is difficult to know where to start engagement.

The Commission notes the additional emphasis on societal impacts in many collaborative models in Europe and the United States. This is a point of difference from the Australian models and sets these models apart in terms of collaboration strategies and outcomes as academics essentially share in the achievement of the outcomes. Funding bodies in many countries require bidding academics to provide evidence of societal impact (and not just on the academic community), understanding how engagement results in such benefits, while simultaneously maintaining scientific quality. Grant streams of the ARC have moved in recent years to including criteria such as societal impact, community engagement and broader application of research.

In the Australian context individual discretion and research curiosity have historically been the main determinants of collaboration. Potential collaborators need to focus the conditions under which engagement generates both academic and industrial benefits, to minimise the risk of failure and ensure that collaboration occurs on a meaningful and long-term basis.

Box 6.1 provides an example of holistic industry level–researcher collaboration in South Australia. While it may not be replicable or appropriate for other industries, the Waite Research Precinct is an example of structural arrangements and partnerships overcoming and making worthwhile differences in motivations and outcomes for business and researchers.

Box 6.1: The Waite Research Precinct, SARDI and Agribusiness R&D

The Waite Research Precinct (the Waite Precinct) includes some of the state's leading research institutions in agricultural sciences and can trace its history to the establishment of the Waite Agricultural Research Institute in 1924. The Waite Precinct is intended to foster collaboration between research organisations in the public and private sectors.

The South Australian Research and Development Institute (SARDI), which was established in 1992 as a business unit of the Department of Primary Industries and Regions South Australia, is the South Australian Government's only research institute devoted to the agricultural sciences. It currently employs around 300 FTEs, the majority of whom either undertake or support research arranged under four broad thematic clusters: aquatic sciences; crop sciences; food sciences; and livestock sciences.

SARDI's head office is located on the University of Adelaide's Waite campus, where it is a major contributor to the wider Waite precinct, along with major Australian research organisations including CSIRO and the University of Adelaide's Waite Institute, among others. These institutions collectively form one of the world's largest research precincts devoted to agribusiness and agricultural science. The precinct is focused on, and supports the commercialisation of, research into plant biotechnology, sustainable agriculture, wine, food, cereal breeding and land management. The Commission notes that SARDI's research program benefits from several close collaborations with research partners and affiliates within the Waite precinct, including:

- Australian Genome Research Facility (AGRF);

- The University of Adelaide's School of Agriculture, Food and Wine;
- The Australian Wine Research Institute;
- Food SA;
- Wine Innovation Cluster; and
- Terrestrial Ecosystem Research Network.

SARDI's collaborative linkages and networks have facilitated a range of national and international research collaborations, program and projects. They include: SARDI's association with the Goyder Institute for Water Research; its contributions to the Great Australian Bight research program, where its partner organisations include CSIRO, the University of Adelaide and Flinders University; and the Fight Food Waste Cooperative Research Centre, in which its partners include major research-intensive universities like the University of Queensland and the University of Adelaide. The Commission notes that SARDI is also a central partner in the Australian Plant Phenomics Facility, which is funded under the Australian Government's NCRIS initiative, and the South Australian node of the ARC's Centre of Excellence in Plant Energy Biology. Both research clusters are based within the Waite precinct.

The Commission notes that SARDI, since its foundation nearly thirty years ago, has increased its focus on those research areas aligning more with South Australia's agribusiness sector. The evolution of its research agenda has been guided by strategic priorities set at both the state and national levels, including economic development initiatives like the state government's Growth State. On a national level, the National Primary Industries Research Development Extension Framework is a recent and significant catalyst behind the redirection of SARDI's research priorities.

The Commission notes that South Australia appears to perform well in citation metrics related to agricultural sciences. The category normalised citation impact for the agricultural and veterinary sciences, for instance, shows that the state's performance is consistently above the world average, with South Australian research in these fields showing consistent improvement over the last decade. In addition, the percentage of agricultural science publications produced by South Australian researchers in the top one per cent of publications worldwide is substantially above the Australian average.

It is difficult to determine a causal relationship between the state's comparatively strong performance in the agricultural sciences and SARDI's engagement with research partners in the Waite precinct. That said, the Commission notes that the interaction within the precinct of diverse research partners from industry, the Australian Government and the university sector is likely to have enhanced SARDI's capacity to support priority R&D outcomes for the state.

Source: Annual reports of SARDI and the Waite Research Institute and ACIL Allen Consulting SARDI Review, Report to the Department of Primary Industries and Regions, October 2016.

6.2.6. Conclusions

Collaboration mechanisms

The Commission places great importance on industry and the universities working with the state government to review and enhance the collaboration mechanisms and their sector coverage to ensure that the mechanisms enable the parties to concentrate on areas of

strength, are geared towards extracting value and promoting growth, while also enabling more businesses to engage in the transfer of knowledge. A key theme of this report is that while South Australia in the main does some things well, it needs to do more in the areas in which it has resources and expertise on a sustained basis to reap the benefits. The Commission notes South Australia's R&D capabilities are not at the level where resources can be allocated across many fields as this dilutes the effectiveness of effort.

Both university and business stakeholders have expressed support for mechanisms that reduce the barriers between research institutions and business. Such mechanisms include:

- informal and formal collaboration events and networks;
- media platforms to exchange information;
- the employment of graduates and PhD researchers;
- challenge events on key areas or projects of interest to the state; and
- industry-funded positions, endowments or seed funding for research.

Collaborative bridging mechanisms can only be successful in the presence of commitment, both financial and cultural over the long-term, accompanied by clear responsibilities, aims and performance measures.

The Commission considers that such schemes merit consideration as part of the South Australian Government's response to the EXCITE strategy, announced by the South Australian Office of the Chief Scientist. This will be discussed in more detail in Chapter 7.

Collaboration intermediaries

If policy aims to successfully increase the impact of academic research through fostering engagement, both universities and firms need to be skilled in initiating and maintaining such collaborations. Firms also need to recognise that collaborating with academia presents distinct challenges for them, separate to those of customers or suppliers.

As discussed in section 5.1 on infrastructure, one of the well-received and well-attended aspects of the Bioscience precinct were the networking events run by Bio Innovation SA and later TechInSA. Stakeholders have emphasised the importance of formal and informal networking that bring together research providers, technology developers, entrepreneurs, investors and government bodies, thus helping to form teams interested in commercialising new technology. The BioSA model also enabled development of proof-of-concepts and leveraged project funding from all sectors, created a pipeline of technologies available for commercialisation and provided a supply of experienced staff to support networking and collaboration of investors, companies and researchers.

While the BioSA model was applied to the health and medical sector, there is potential to apply it more broadly to other sectors. The value of such intermediary, brokerage services and the expertise of sectoral representatives independent of researchers, investors and companies has been identified to the Commission by business stakeholders.

The Commission notes the recent South Australia Government commitment of $7 million to support external innovation and translation intermediaries to enhance industry-research collaboration and initiatives such as industry Doctoral Training Centres and Frontier Technology Capability Centres.

Based on initial results, the Commission considers merit in the state government expanding the model of external innovation and translation intermediaries to include brokerage services and sectoral representatives aligned to research strengths, to ensure greater benefit to industry and researchers. Chapter 7 contains recommendations to address these issues.

7. Path to performance

The Commission's terms of reference require it to consider and report on R&D performance; how it translates into economic performance and wellbeing in the state; and recommend actions that the South Australian Government might take in connection with South Australian-based R&D to increase:

- the output and productivity of South Australian-based publicly funded R&D;
- South Australian-based private sector R&D, and in so doing;
- the state's:
    - share of Australian Government funding for research; and
    - rate of economic growth.

This chapter sets out the Commission's conclusions and recommendations on these matters in the context of the South Australian Government's Growth State strategy, its associated growth sector plans and the government's EXCITE strategy to attract new research investment across the fields of STEMM to deliver innovative products and services.

The recommendations build on and complement these strategies, including by strengthening the South Australian Government R&D architecture necessary to elevate R&D to a strategic role in lifting the state's economic growth and productivity.

The first part of this chapter sets out the Commission's conclusions on R&D performance and how it has translated into economic performance and wellbeing.

A key point is that the SA economy has had for at least a decade the second highest R&D intensity (2 per cent of GSP) of the states but the state's productivity performance has lagged Australia as a whole. This argues increasing the overall level of spending on R&D in SA is secondary to increasing R&D output and productivity from existing resources.

The Commission reviewed the history of SA Government support for R&D activities over the past four decades. There were examples of consistent long-term support in selected sectors – particularly agriculture. But the predominant picture was of much churn in programs, redirections of effort, policies (health in particular) that reduced the capacity and productivity of R&D; and, apparently, little attention to performance, measurement and evaluation. Moreover, a good deal of the R&D has not been linked to downstream translation and innovation in the SA economy's key sectors, such as health, as the Commission found in its inquiry into health and medical research.

Accordingly, the Commission has concluded that R&D has, in practice, not been well harnessed to be able to play a strategic role in improving economic growth and wellbeing in South Australia over the past two decades. Addressing this is important for the state's future.

Two conclusions follow in the Commission's view.

First, for R&D to be a strategic enabler of the state's performance, a consistent, long-term position on the strategic contribution of R&D and the actions available to the SA Government to pursue it is essential. This includes ensuring those actions are directed to strengthening upstream basic R&D in terms of excellence, output and productivity and strengthening its

connection to downstream translation and commercialisation in the sector value chains. These are key themes of both the Growth State and EXCITE strategies.

Those actions, in the Commission's view, most importantly consist of the following policy instruments:

- government spending on its own research, programs to encourage R&D by business and support for research in universities;
- investing in and managing the government's research infrastructure assets, including opening access to its own data for research;
- building the capability of the government's own research workforce and encouraging research bodies to act similarly, with particular focus on having outstanding research leadership;
- building and leveraging relationships with research bodies in SA and beyond, the Australian Government (in relation to its research activities in SA and national programs) and external and international bodies; and
- the SA Government's own procurement of goods and services.

The Commission's evidence and analysis supports the relevant elements of EXCITE, especially in relation to research infrastructure and addressing research and innovation precincts. Accordingly, the Commission's recommendations on specific policy actions are limited to additional matters including data access, research workforce and procurement.

The second conclusion is that, given the history of the state's policies, an effective SA Government architecture for R&D is a prerequisite. In particular, this means a stable, effective regime for executing the strategy that embeds accountability, budgets, timeframes, measures and evaluation in agencies; and ensures R&D is integrated into the relevant growth sector plans. This is a key theme in the second part of this Chapter.

7.1 SA's R&D performance and contribution

This section begins with an overview of R&D spending in South Australia; sets out the Commission's three level performance assessment; and provides the Commission's conclusions on priorities for action.

7.1.1 R&D spending in SA

Total expenditure on research in South Australia is relatively high. The total amounts to nearly 2 per cent of GSP, which is an intensity second only to Victoria. The broad picture is that the two largest managers of research expenditure in the state are universities (approximately $800 million, which includes $340 million of Australian Government funding) and business (approximately $800 million), followed by the Australian Government (approximately $300 million which includes spending on intramural R&D) and then the SA government (approximately $130 million).

The business sector

The business sector spends around $800 million a year on R&D in SA:

- SA is a moderate performer when business R&D expenditure is compared to the size of the state economy (ranking third in state BERD to GSP ratio in 2017-18 but below the Australian average).

- in comparison with their interstate counterparts, SA businesses have a higher propensity to spend on R&D (except in WA), controlling for other influencing factors such as firm size and industry.
- SA's persistently lower total business R&D expenditures, compared to other states, is partly attributed to its relatively high representation of SMEs, which tend to spend less on R&D compared to larger firms.
- it is also a reflection of SA's industry structure because some industries tend to invest more in R&D (such as mining, and professional, scientific and technical services), and these are underrepresented in SA compared to the rest of Australia.

Business expenditure is below the national average, even though firms in the state have a higher propensity to spend on R&D, the issues being industry structure and firm size. While a different industry structure and a different distribution of firm sizes might lead to higher expenditure on business R&D, those factors are outside the Commission's terms of reference.

The higher education sector

The state's three public universities are important sources of research activity, with the potential for new knowledge to spill over to other segments of the SA economy. Expenditure by the higher education sector on R&D in SA has increased substantially, from approximately $500 million in 2008, to approximately $830 million in 2018. Indeed, research expenditure growth through higher education outstripped growth in business R&D and government R&D expenditures both nationally and in SA.

Nevertheless, there are signs the research strength of SA's higher education providers has weakened in recent years, including relative to other states:

- SA's share of Australia's total Higher Education R&D (HERD) expenditure has slowly declined from 7.3 per cent in 2006 to 6.8 per cent in 2018.
- in the same period, SA universities have experienced lower growth rates than the national average in all major sources of funding.
- while the funding received by SA universities from the Australian Government through competitive grants grew at an annual rate of 4.3 per cent between 2006 and 2018, the share relative of national funding dropped from 8.9 to 8.1 per cent.
- between 2014 and 2019, average grants for SA universities have been 12 per cent below the Australian average between 2014 and 2019.

In addition, the general growth in higher education expenditure largely depends on generating its own source funds through teaching cross-subsidies which are highly dependent on international students. While this is less prevalent in SA, it is still a significant risk to R&D spending nationally and in SA, given the barriers to the entry of international students caused by the ongoing response to the COVID 19 pandemic. At the national and state level, universities will need to respond to this situation, and the effectiveness and speed of the local response will affect R&D activity in the local research system.

In terms of the research workforce (see section 6.1.5), the number of person years of effort (PYE) devoted to R&D in SA fell (from 2,067 to 1,848) over the period 2012-2018, compared to an increase in Australia (from 23,305 to 24,805) over the same period. Using ERA

headcount data, staff numbers increased in SA over the same period, suggesting the use of more part-time staff in research and/or more time being allocated to teaching or other duties.

The Australian Government

The Australian Government is a major source of R&D activity in South Australia, both as a funder and through its own direct spending. In 2018-19, approximately 16 per cent of Australian Government expenditure on R&D occurred in South Australia, ranking the state second behind Victoria. While more detailed break up of expenditure is not available at the state level, the Commission understands that a large proportion of this higher expenditure in South Australia is due to the significant presence of Defence Science and Technology (DST).

Since 2006-07, intramural Australian Government expenditure on R&D in South Australia increased by 12.6 per cent, despite total expenditure increasing by only 3.2 per cent. When compared to the size of the state's economy, only the ACT and Tasmania had a higher intensity of Australian Government expenditure on R&D. However, the intensity of Australian Government expenditure on R&D has been declining in all states and territories.

South Australian Government

Spending managed by state and local government in SA relative to GSP is the highest of all the states. The SA Government has been active on R&D policy for many years as shown in Chapter 2. The policy mix includes: in-house spending and grant programs (including forms of procurement); precinct investments and other investments in infrastructure assets; and activities promoting cooperation and collaboration among various research organisations.

In dissecting the state government expenditure in more detail (see Table 3.7) the Commission notes in relation to the state government's spending of around $130 million in 2019-20:

- after removing the external sources of funds, the balance funded by the state government is of the order of $26m in 2019-20.
- excluding SARDI's base funding and the DIS's grant programs, the remaining $14 million was expended by individual agencies in relatively small amounts that vary substantially from year to year (see Table 3.6).
- the DIS spending of $4 million represent most of the funds allocated in a competitive manner.

While these amounts fluctuate from year to year (see Table 3.6), the conclusion is the state spends a small amount of its own funds on research, which accounts for only part of its policy portfolio.

This information is not routinely published in a consolidated form; the Commission gathered the information directly from agencies. The absence of this whole-of-government information is another indication of the weak architecture for the state's R&D activities and sub-strategic role of R&D.

The question remains of whether better use can be made of the funds that the state contributes towards research. That is, would a reallocation of funding between areas increase the productivity of the overall research effort managed by the state? Another question related to the productivity in the application of expenditure is the extent to which that process is contestable. A higher degree of contestability is likely to reveal more productive uses of funds and increase the overall return.

The Commission is not in a position to judge whether the state government's spending and funding differs from other jurisdictions as it was unable to discover any equivalent whole-of-government estimates from other Australian jurisdictions.

The Commission has also considered whether there is evidence of a greater capacity to raise additional research funds from other sources using the state funds as leverage. The funding allocated to support research organisations (like SAMHRI and SARDI) and their operations is one comparison. The purpose of the state allocation is primarily to support operations so that the two institutions can raise additional funding for projects. While SARDI appears to achieve a higher rate of leverage, it is a more mature organisation than SAHMRI whose attributed expenditure and funding is more complex and may also be reflected in university statistics. The Commission was unable to reach any conclusions on this matter.

7.1.2 R&D performance

As mentioned in the introduction, the Commission has evaluated performance at three levels:

- overall productivity growth;
- macroeconomic indicators of research activity and outputs; and
- evaluations at the program level.

Overall productivity growth

While the SA economy has the second highest R&D intensity (2 per cent of GSP) of Australian states, SA's long term productivity performance has lagged Australia as a whole. For two decades, multifactor productivity has been flat and capital productivity has fallen significantly over the past decade (see Chapter 1). This compares adversely with the overall Australian economy where productivity has generally grown over the past decade.

At face value, the high level of R&D intensity in SA has had little impact on the state's poor productivity performance, suggesting several possible explanations including that R&D's output and productivity are low and that it is weakly linked to downstream translation, commercialisation and business.

Macroeconomic indicators of research activity and outputs

The Commission examined indicators of the performance of the research and development system in the state, related to the level of activity and its outputs and processes. Table 7.1 sets out a selection of 'macroeconomic' indicators of the performance of the research system at the state level. They are drawn from Chapters 3, 4 and 6.

The indicators show positive trends in higher education spending and publications from that sector, including international collaborations, which are highlighted in Table 7.1. Indicators showing negative trends are the decline in the amount of and share of category 1 income and the reduction in academic staff devoted to R&D.

Some fields of research have strong elements of performance, including the quality of publications. According to the national research assessment (ERA), many research fields are performing at global level. In some areas, there is concern about their scale and fragility.

Other indicators considered were the role of the research workforce, in terms of its size and composition and the extent of collaboration among academics and with industry (since collaboration is expected to raise productivity). One weak point is that the size of the research workforce has been falling.

Table 7.1 Summary of R&D performance indicators (various years)

Indicator	Year	Current	10 years previous	Trend
Academic staff devoted to R&D (PYE)	2018	1,848	1,688	
University total research workforce [a] (PYE)	2018	5,300	4,523	
Australian Government expenditure ($m)	2018-19	340	308	
Business expenditure on R&D ($m)	2017-18	798	948	
No. patent applications	2019	444	605	
SA share of patent applications (%)	2019	5.2	6.2	
Higher education expenditure on R&D ($m)	2018	827	505	
SA Universities income from ARC ($m)	2018	38.2	33.1	
SA Universities category 1 income ($m)	2018	125	99	
SA Universities share of ARC income (%)	2018	6	6.5	
SA Universities share of category 1 income (%)	2018	7.5	8.6	
No. publications in the top 10% of citations	2019	1,047	515	
Publications with an industry co-author (%)	2019	1.9	2.4	
Publications with an international co-author (%)	2019	58.3	41.1	

a: Total research workforce includes academic staff, postgraduate students and other staff

Source: ABS 8109.0, ABS 8111.0, ABS 8104.0, Department of Education, Skills and Employment HERDC, Clarivate Incites Database, IP Australia

Since 2014, the average grant size in Australian Research Council programs for South Australian universities has been lower than the Australian average. It is closer to average for programs such as Discovery (led by individual researchers or small teams) and Linkage (where researchers and other organisations work together). It is small for larger programs like Centres of Excellence.

In addition to grant sizes, the Commission also examined success rates. It found a lesser performance in this respect, including in the Discovery program (although with some exceptions in other programs). South Australia has not been awarded any new funding through the ARC Centres of Excellence (CoE) program since 2014 (and South Australia submitted only one application in this period). Laureate fellowships awarded to senior staff and Future Fellowships awarded to mid-career staff also show low success rates.

The Commission interprets these results to mean there is a comparative weakness in research leadership in South Australia. This view was expressed by several participants in the inquiry.

Agricultural research in SA is an example of a high performing field. The specific data for South Australia and the more general results suggest that the agricultural research effort in

the state has been high-yielding. Given the size of the sector in the state economy, the effect on overall state productivity growth is small.

The extent of local collaboration has not been a focus of the work of the Commission. Its view is that the extent of international collaboration is an important driver of research quality. However, future assessments of the performance of the SA research system may wish to consider local collaboration and the scope for it to contribute to resolving issues of scale in research fields.

The extent of international collaboration was noted as a strong point in performance relative to other states, but Australia's international collaborations are relatively low compared to other OECD countries. Collaboration with industry in SA is relatively poor by global standards but consistent with the experience in other states. This is an important issue as it impedes the downstream translation of research into commercial applications.

Overall, from a state perspective while the R&D in the public universities has strengths and weaknesses, it faces some specific challenges relevant to the gamut of the SA Government's R&D strategy and activities. They include the need for outstanding research leaders to enable the state to be competitive in Laureate Fellowships and Centres of Excellence among other areas. Stronger links to downstream translation, commercialisation and business are also needed to lift the dividend to the state in terms of growth and employment from R&D efforts that are not directly within the state government's influence (while it has some capacity to influence through its investment in precincts and procurement). The Commission notes that the universities are taking some steps to lift the impact of their research and to better connect with business.

Improving the performance of this part of the R&D engine is an essential element of a whole-of-state pathway to lifting the contribution from R&D. The Commission considers this justifies dedicated attention at a strategic level in government as part of or in conjunction with its Growth State and EXCITE strategies. The Commission reached a similar conclusion in relation to its health and medical research in its recent inquiry and recommended elevating the strategic focus of HMR to increase the level and improve the effectiveness of R&D in that sector.

Evaluations at the SA Government program level

An important part of the state government policy on research involves support for various other programs and activities which concern research. To identify these activities, the Commission examined the policy statements in relation to research and reviewed programs designed to implement those policies including the Growth State plan released in 2019.

In Chapter 2 the Commission found there has been a considerable amount of activity by the state government, but also a lot of churn, with many programs being short-lived, measures being adjusted, and spending being regularly redirected. Table 7.2 refers to the SA Strategic Plans that applied from 2004 to 2012 and shows:

- the adoption of new programs (compare columns one and three);
- the shifting of targets (columns three and five) and the lack of specificity of the targets;
- the slow progress in some projects; and
- the lack of clarity concerning the outcomes of some projects relative to the targets.

Table 7.2: SA Strategic Plan: Objective 4 (Fostering Creativity and Innovation) — selected R&D-related targets and their outcomes

Targets at 2004	Reported status as at 2007	Changes to targets in 2007	Reported status as at 2010	Changes to targets in 2011	Reported status as at 2012
Increase patent applications to exceed our population share of all Australian applications within 5 years	**Little/ No/ Negative Movement**	**Old target ceased and new target set to:** *Increase gross revenues received by SA-based research institutions from licences, options, royalty agreements, assignments, licenced technology patents by 2010 (baseline: 2005)*	**Progress: Negative Achievability: Within Reach**	**Target modified** — previous target it did not measure the cumulative quantum of research dollars entering SA. **New target set to:** *Total gross cumulative value of industry and other funding for research earned by universities and state-based publicly funded research institutions to reach $650 million by 2020.*	**Progress: Baseline established** (1)
Exceed the national average of Business Expenditure on R&D (BERD) as a % of GSP, and approach the OECD average within 10 years (2)	**On track**	**Old target ceased and new target set to:** *Increase business expenditure on R&D to 1.5% of GSP in 2010 and increase to 1.9% by 2014 (baseline: 2000-01)*	**Progress: Positive movement Achievability: On Track**	**Target modified —** Timeframes were extended to be more realistic, but still ambitious. **New target set to:** *Increase business expenditure on R&D to 1.5% of GSP by 2014, and increase to 2.0% by 2020.*	**Progress: Positive Movement Achievability: Unlikely —** Data suggested that the GFC led to a downturn in R&D investment (3)
Have based in SA either the headquarters or a major node of at least 40% of all existing CRCs, Major National Research Facilities and centres of Excellence within 5 years (2)	**ACHIEVED**	**As the target was achieved, a new target set was set to:** *Secure Australian government research and development resources to 10% above South Australia's per capita share by 2010 and increase this share to 25% by 2014, for both public and private spheres (baseline: 2000-01)* (2)	**Progress: Unclear Achievability: Unclear**	**Target modified —** to better reflect the full range of federal R&D funding: **New target set to:** *Increase the gross value of university research income to 20% above SA's per capita share by 2014 and maintain thereafter*	**Progress: Positive Movement Achievability: On track**
Improve the connections between educational institutions and industry to enhance creativity and innovation	**Unclear**	**Target ceased** — measurement was problematic and community engagement process did not support retention of the target.			
		New target added: *The proportion of SA businesses innovating to exceed 50% in 2012 and 60% in 2014 (baseline: 2003)*	**Progress: Unclear Achievability: Unclear.**	**Target ceased** — due to difficulty in data collection and defining innovation.	
		New target added: *By 2010, public expenditure on R&D as a % of GSP to exceed average investment compared to other states (compared to baseline: 2000-03)*	**Progress: Positive movement Achievability: ACHIEVED**	**As the target was achieved, a new target set was set to:** *Public expenditure on R&D, as a % of GSP, to be maintained at 1.2% to 2020*	**Progress: Baseline established**

Sources: SA Government, South Australia's Strategic Plan: Creating Opportunity (2004); SA Government, South Australia's Strategic Plan (2007); SA Government, In a Great State: SA Strategic Plan (2011); SA Government, South Australia's Strategic Plan: Progress Report (2012)
Notes: (1) SAPC review of HERD data indicates the target for university income for R&D was reached (HERD in SA is currently over $800 million); (2) This was also an STI[10] target; (3) SAPC review of BERD data indicates that SA reached the BERD percentage to GSP national average in 2006-07 and no other year in the 10 years to 2014, and has never met the OECD average in that period

The Commission found relatively few evaluations of the R&D components of state strategy. The review of SARDI in 2016 was an exception. The Commission examined other assessments but was concerned with some of the indicators of performance that were used. Overall, the Commission found few routine evaluations and found that when an evaluation has been undertaken (other than the case of SARDI) it either found significant points of criticism or its value was limited by poor methodology. Review, evaluation and performance measurement are not strengths in this area of public policy, which significantly restricts the capacity to take an evidence-based approach to government decision-making.

Two business related programs are of particular interest to the Commission. They are, firstly the elements of the Research, Commercialisation and Start up Fund which involve basic research to prove and develop concepts for new businesses. Second, the Commission is interested in the Go2Gov program which was recently established to encourage small firms to assist government agencies in responding to major challenges.

Similar schemes are used in other countries, and by the Australian Government. Assessments of these schemes in SA are not available, but those applied to such schemes in the US are positive. In the Commission's view, these schemes are worthy of additional attention including how they might be managed to complement those at national level. This is part of developing further the strategic relationship with the Australian Government.

The Commission also examined the contribution of investments in physical infrastructure to performance. The evidence of the contribution of the innovation precincts is difficult to determine. The Commission was unable to source any quantitative evaluation of the precincts' effectiveness in increasing R&D activity on the site or in the state. Businesses located on the sites anecdotally vouched for the importance of the precinct in their development. In Commission's view, precincts can play a role in connecting business with research providers, and in facilitating virtual interaction as well as face to face interaction. In addition, there has been some feedback that for some state-managed precincts, R&D was not a core focus of the development.

A key task at this point is to put in place the conditions, including governance, for driving effective cross-fertilisation and linkages between research and business. The design of new forms of governance of the precincts is identified in EXCITE, and in the Commission's view, is an urgent priority. A better networked set of precincts in terms of research interaction would add further value to their contribution, which is another matter which can be taken up in the design of governance arrangements. At same time, attention to alternatives will be important, and these include schemes which engage directly with business rather than via a spatial intermediary.

7.1.3 Conclusions

In summary, SA Governments have pursued a range of R&D policies and related programs over time and have made significant annual expenditure, both managed and funded by the state, linked to research activities. Some of this self-funded expenditure has evidently had significant positive consequences, especially in agriculture and to a lesser extent in health. And the state has supported areas of acknowledged excellence and world class performance such as the Australian Institute of Machine Learning and the Waite Precinct/SARDI. Overall, following inspection of the data and information at both the policy and program level and at the macro level, the Commission's view is that a more purposeful approach to research policy would lift the return to the state and make R&D a strategic contributor to the state's success. Such an approach would include attention to the activities that have direct impacts on research outputs (as now occurs in health and agriculture), its ownership and

management of its research infrastructure assets, using state spending to leverage additional activity by business, the universities and the Australian government. The EXCITE strategy incorporates many of these elements.

That said, despite the continuing high flow of activity each year in other areas, the Commission is unable to conclude with clarity that state polices have been effective in encouraging research in the state. In part, this assessment is because of the presence of other drivers of research activity. But also, importantly, this assessment is more difficult because of the lack of information available at the program level with which to make an assessment, as evident in the earlier discussion of performance indicators and evaluation reports. This is one symptom that R&D plays a non-strategic role in the state's economy and in historical policies.

There are other significant symptomatic weaknesses including:

- no visibility of the state's whole-of-government spending on, and funding for, research and development;
- patchy information on the performance of, and returns from, the state's research and development activities. While there is solid evidence in some areas, there are complete gaps in others;
- no complete, transparent picture of the state's investment in research and development infrastructure and its impact on R&D. In saying that, the Commission notes that some of this infrastructure has multiple purposes;
- no evidence to make systematic, evidence-based comparisons of the economic and social returns to South Australia from the alternative activities available to the government. The investment in research and innovation precincts by successive state governments is one example; and
- evidence, including from the Commission's health and medical research inquiry, of patchy, and overall insufficient, attention to the strength and depth of the state's research workforce.

In the Commission's view addressing these weaknesses is a necessary condition for elevating R&D to a strategic contributor to the state's economic growth and productivity. Not to attend to these weaknesses significantly risks continuing the policy instability and churn evident over past decades.

The terms of reference ask the Commission to recommend actions that the SA Government could take in connection with R&D so that policy translates to increased output and productivity in this state.

The simplest response would be to recommend that the SA Government spends more money on R&D. The Commission has chosen not to make a recommendation along those lines.

While it is likely, in the Commission's view, that increased overall spending may be beneficial in the future, addressing opportunities to improve R&D policy and making existing efforts by the SA Government more effective across several domains are the immediate priorities. The improved governance and information from addressing these priorities will enable the SA Government to make better decisions informed by evidence about R&D, including where additional resources can be justified and where existing resources can be redeployed.

The next section makes recommendations to address these matters along with recommendations for specific policy actions that would assist R&D efforts by universities and businesses.

7.2 Recommendations

The Commission's starting point

Consistent with its views in the SAPC health and medical research inquiry, the Commission starts from the position that research and development is an essential element of South Australia being a vibrant, modern and competitive state. The benefits come from research and development that, across short to long-term timeframes:

- improves the quality of and productivity of services to South Australians, such as those provided by government; and
- is an essential foundation for key sectors in the state's economy.

It also encourages excellence and growing capability in the research workforce and in the businesses and organisation with whom they collaborate. The benefit to the state comes from higher paid jobs and the flow on to living standards, employment and productivity.

The SA Government through its Growth State Strategy, the associated sectoral plans and the EXCITE strategy has established innovation and skills as a key enabling strategy to lift South Australia's economic growth and productivity. The Commission's conclusions align closely with the priorities of the EXCITE strategy as they relate to R&D, including its emphasis on research excellence, collaboration and an enabled future research workforce. The Commission agrees with importance of the sectoral value chains linking research, development, innovation and translation as the basic mechanism by which upstream research contributes to employment, economic growth and productivity. The priority given in EXCITE to ensuring that the growth plans for priority industry sectors in South Australia are underpinned by a high performing research and innovation value chain is appropriate.

The Commission also notes EXCITE is at an early stage of implementation, with much work identified and remaining to be done.

The Commission's approach is to recommend some additional policy actions and steps to strengthen the South Australian Government's policy architecture to:

- focus on lifting the performance of the state's research and development effort; and
- integrate research, development and innovation into areas of focus for economic growth.

In devising these recommendations, the Commission has applied five principles.

First, the state's R&D strategy needs to take a state-wide, cross-sectoral and 'all-technology' view that has regard to the totality of R&D conducted in the state. This includes incorporating other disciplines beyond STEMM, noting for example, the power of research in social sciences to improve public policy in public provided services such as health and education. This principle also provides the test for the state's own policy instrument settings that they do not work against the strategy.

Second, when devising the strategy be prepared to set priorities that are relevant to the state while retaining the flexibility to respond to advantageous or changed circumstances.

Significantly increasing the contestability for the government's funding is part of this principle to ensure there is ongoing review of the effectiveness and efficiency other allocation of the state's resources in this area. Contestability may be in the mechanism for delivery once directions are set or in the choices of priority areas. In neither case compromise on excellence of R&D.

Third, the long-term character of research and its inherent riskiness calls for strategies with a series of time horizons that drive decisions about whether to continue investment in particular areas and a framework for risk management.

Fourth, policies need to be simple, transparent and accountable, with clear purpose, explicit budgets, relevant performance metrics and evaluation.

Finally, collaboration adds to the locally available bench strength through working with business or local collaborators and by facilitating access to research and partnerships elsewhere that might be relevant locally. As such the R&D strategy needs to encourage collaboration.

The Commission recognises that basic research is part of a chain of value adding activities that ultimately contribute to innovation, productivity and growth, and that whatever architecture is put in place to bolster the performance of the upstream part of that chain should be easily adapted to downstream activity.

The Commission also concluded that a statement specifically for research and development that explicitly complements EXCITE, given its early stage of implementation, would be useful in ensuring a transparent and accountable focus on the research and development 'engine room'. Such a statement would strengthen accountability for state's research and development activities, strengthen the capacity to deliver the EXCITE strategy and elaborate further on the relevant EXCITE themes. The proposals here also elaborate further with respect to the consideration of whole of government approach, the specification of objectives, the collection of measures of performance and systems of evaluation.

Accordingly, the Commission summarises its recommended approach as follows:

- establish, with clarity and visibility, the intended strategic role for R&D in South Australia's future with some specific goals in priority areas. The Commission sees this as a further elaboration of elements of relevant parts of the EXCITE strategy.
- integrate this enabling role into all relevant parts of the state's economic development strategy, covering the state's direct activities as well as its indirect activities such as its relationships with the research institutions operating within South Australia, including those of the Australian Government;
- strengthen the research and development system architecture to better pursue the state's research and development goals by:
    - systematically identifying, measuring and tracking the resources the state commits to research and development and the return from those resources, including its research infrastructure assets;
    - establishing a state-level budget for research and development activities by the state with clear performance goals, performance measures and accountability devolved to agencies;

  - over time, lift the contestability for the state's funding of research and development based on evidence and performance; and
  - review the justification for additional budget over time.

- declutter the regulatory framework governing research – further detail is in the Commission's recommendations in its health and medical research inquiry – including greater access to state-held and generated data;
- build systematically and purposefully, a step change in the capability of the parts of the state's research workforce that the SA Government directly employs or indirectly influences and encourage research institutions to do likewise; and
- use its procurement to selectively provide opportunities for innovative solutions, including those built on SA research and development.

Recommendations 7.1 sets out the high-level framework for addressing the first three of these points.

Recommendation 7.1: Overall framework

To add to the contribution of research and development to growth in South Australia, the Commission recommends that the South Australian Government:

- establishes long term state-wide goals for lifting the volume, productivity and economic impacts of R&D, sets quantitative targets, such as the state share of national grant funding, collaboration with business and rates of commercialisation, to guide progress towards those targets;
- designs, strengthens and implements accountability, budgets, measurement and evaluation to support the delivery of this vision, including through the state's sectoral growth plans. In this respect the activities available to the state government include expenditure directly related to research, procurement (and its elements that have a research component), management of assets relevant to research and management of relationships with others in the state who contribute to research activity, including the Australian government, business and universities;
- strengthens the government's architecture for R&D to pursue these goals and the accountability for their delivery;
- makes a state government strategic plan for research and development addressing all the tools available to it, including: expenditure directly related to research; government procurement and its elements that have a research component; management of assets relevant to research; management of strategic relationships with others in the state who contribute to research activity, including the Australian government; business and universities; and building the capability of the government's own research workforce and encouraging research bodies to act similarly; and
- incorporates in these actions the scope to develop existing partnerships, the role of precincts, policy on use of public data, the scope to apply procurement policies and attention to research leadership.

The Commission concluded that, given the churn and instability of SA's public policy for R&D over recent decades, an effective accountability framework to support the delivery of this vision is essential. This framework needs to have clear goals, clarity of objectives, budgets, ongoing review and the capacity to allocate resources to the highest benefit to the state in terms of growth and productivity. Rigorous evaluation is a necessary element to ensure policy decision makers can make evidence-based decisions.

The accountability framework would include a transparent set of indicators that describe trends and performance of the state's R&D, including the government's own activities and the resources committed to them. The Commission considers the measurement framework needs to be designed by independent experts, and the indicators published regularly with independent expert commentary. These are very important tasks. The macroeconomic measures in Table 7.1 are an indicative, highly selective starting point, the EXCITE strategy identifies a range of indicators and the Commission received advice from several participants about current practice in universities and elsewhere. The indicators need to include information on SA Government expenditure and funding such as set out in Table 3.6.

Regular assessment and reporting are integral to ensuring government has a clear understanding of performance and alternatives. Noting that much research and development is long term, reporting timeframes need to be appropriately set.

Recommendation 7.2 sets out the elements of this accountability framework.

Recommendation 7.2: Accountability

To make operational the vision in which research, development and innovation is accepted as a contributor to long run growth, and building on EXCITE and other relevant policies, the Commission recommends that the South Australian Government establishes a clear, transparent accountability framework in which:

- clear state-wide goals for research and development in the short run and in the long run are adopted;
- the intended purpose and the nature of the benefits in the short and the long term of each of the state's actions in all agencies to support and increase research and development is clear;
- the actual contribution from, and performance of, the state's actions in all agencies to drive that contribution is measured and evaluated systematically and reported transparently;
- principles that support the efficiency of actions related to research and development are shown to have been applied such as:
    - contestability in deciding the composition of the state's portfolio of support for research and development, including its infrastructure assets; and
    - systems of gateways and milestones for the assessment of project progress;
- an independently designed set of transparent performance indicators for understanding the overall performance and trends in the state's R&D performance is established, with ongoing compilation, regular publication and commentary on performance in work led by external independent advisors.

These measures include whole-of-government resources committed to research and development, including recurrent expenditure and research and development assets, and the performance of those activities.

Strengthening the state's R&D architecture

The Commission concluded that the totality of SA public policy for R&D points to a critical missing link in SA's R&D policy framework being consistent, strategic leadership — ensuring that the different elements of policy work together to optimise impact. This leadership integrates both 'top down' whole-of-government perspective with 'bottom up' agency and sector perspectives.

There is no shortage of policies and programs, implemented across SA and Australian Government agencies, designed to lift R&D activity in this state. These have promise, but churn is evident. Policies and programs tend to fade away over time, without any understanding of their impacts and outcomes, and with agencies losing sight of their original objectives. Other policies, which appear to be more current or topical, take their place.

The Commission concluded the architecture for R&D is weak in terms of its capacity to set and prosecute a whole-of-government R&D policy and is not fit for purpose. In practice the architecture appears to support a largely bottom up approach, with priorities and decision-making being vested in agencies where the majority of R&D funding, capability and infrastructure reside. Important decisions on how the scarce resources of government are allocated are driven within individual agencies, making it difficult for policy makers to operate in a truly strategic manner. The Commission concluded that elevating and consolidating strategic decision making within the architecture of government is a necessary step to sharpening the efficacy of SA R&D policy.

The Commission considered several possible options and was assisted by the feedback and advice from inquiry participants. One option could be to assign strategic responsibility for R&D policy within a single ministry. Another option could be to create a new mechanism that requires R&D policy across portfolios to be monitored and regularly reviewed. A key consideration was to identify an approach that did not add a further layer of bureaucracy and decision making and did not diminish the accountability of line Chief Executives for delivering their objectives including sector growth plans.

The Commission opted for an approach that: effectively integrates the contribution of research and development into sectoral plans; establishes a whole-of-state strategic perspective on the contribution and performance research and development; and considers strategic options for the state.

It concluded that a strong Ministerial level focus on the state's whole of government R&D activities would strengthen attention to the health and effectiveness of the state's R&D foundations and emerging future opportunities. Executive accountability for delivering sectoral growth plans, including ensuring their R&D foundations were fit for purpose, would rest with agency chief executives to avoid any suggestion of creating an additional layer of decision-making or bureaucracy.

A Chief Advisor with a strategic scope for all research, development and innovation would support the Minister, with strong authorities including to: advise on R&D strategy and the effectiveness of R&D in industry sector plans; have access to and commission independent

and rigorous evaluation; and sponsor a community of practice among R&D professionals. It would also encompass areas of research beyond STEMM that can improve the performance of the SA economy, including government services.

In practical terms, this is an expansion and strengthening of the role of the Chief Scientist. It would be a strong advisor role that would work highly collaboratively with agency chief executives and their agencies who, in turn, would be accountable for working collaboratively with the Chief Advisor.

The Commission proposes that this Minister would be assisted by an broadly based external independent, expert advisory body with a strategic perspective, with the majority of members coming from outside South Australia. The activities of this body would include: the design of the set of performance indicators and information proposed in Recommendation 7.2; compilations and publication of the information; expert, independent commentary on the performance of SA R&D; and advice to the Minister on issues requiring attention, such as areas of weakness, including recommendations for investigative work. The Commission envisages the Minister would, as appropriate, ask the Chief Advisor and/or relevant Chief Executive to respond. This body could also validate the design of proposed evaluations of SA Government programs and receive a copy of the evaluation reports when completed. To manage the inherent conflict between the roles of this body (review and assessment) and the Chief Advisor (strategy and implementation), the Commission considers the Chief Advisor ought not to be a member of the independent body although clearly both will work closely.

The Commission considers strong independence for the expert advisory body, underpinned by statute, is essential to maintaining a long-term, strategic and objective focus on the health and performance of the state's R&D effort.

Recommendation 7.3 sets out the proposed architecture, which strengthens, extends and clarifies the state's current architecture. Over time this structure can evolve to include complementary institutions with a greater focus on translation, but which would be within the remit of the Minister. Their design however is beyond the scope of this inquiry.

Recommendation 7.3: Strategic architecture for research and development activity

To implement the accountability regime, the Commission recommends that the South Australian Government establish a strategic architecture for this purpose which, considering the principle of avoiding the introduction of an extra layer of management to existing arrangements, links:

- a Ministerial level responsibility for Research and Development as a key part of the overall Innovation and Skills portfolio linked to the state's innovation and skills strategy;
- a Chief Advisor for Research, Development and Innovation;
- an expert Independent Advisory Body for Research, Development and Innovation; and
- Chief Executives of relevant agencies.

The Minister is accountable for improving the contribution to South Australia from its research and development activities, including by:

- developing and proposing a whole-of-government Strategic Plan for research and development in recommendation 7.1 for consideration and approval by the South Australian Government;
- oversight of progress against the plan, including the performance of agencies in improving their activities and executing the state's growth strategy and the outcomes achieved; and
- publicly reporting progress against the plan.

The Chief Advisor advises the Minister and the government on research and development matters and related matters including:

- engage with government agencies, the Australian Government, business, research institutions and other relevant stakeholders on matters pertinent to the strategy or related matters;
- lead the development of the whole-of-government Strategic Plan for research and development in recommendation 7.1;
- advise on the South Australian Government's support for research and development including its integration into the state's growth strategy and relevant growth sector plans;
- encourage rigorous evaluation of research, development and innovation activities of the South Australian Government and have access to all such information; and
- sponsor a community of practice of the senior agency officials who are accountable for research and development in their agencies.

The Independent Advisory Body provides the Minister with expert, independent advice on the state's strategy and strategic opportunities, and provides oversight and commentary on South Australia's research, development and innovation performance in recommendation 7.2. It also leads the design of the performance measurement framework includes transparent reporting on targets, budgets, performance measures, evaluations and resources among other matters. Half of the membership would come from outside the state. The body would be given strong independence through statute.

Agency Chief Executives are accountable for effectively integrating the government's research and development activities into the relevant growth sector plans and other relevant activities for which their agencies are accountable.

Strategic relationships, infrastructure and collaboration

The Commission notes the importance of collaboration in the EXCITE strategy, with which it strongly agrees.

The Commission's research shows that, overall, SA Government funding reflects only a small proportion of all R&D spending in South Australia. The Australian Government provides

the majority of funding, especially through its major research institutions CSIRO and DST. While SA government agencies aim to work in tandem with national policy (e.g. the Department of Innovation and Skills works as a conduit to Commonwealth agencies on national R&D-related policies, and Defence SA is a conduit on national defence policy), the Commission concluded that the Australian government expenditure in South Australia by its research institutions is a potential asset for South Australia.

Developing the relationships with Commonwealth agencies in the state with a view to enhancing their contribution to economic growth and productivity is an important priority, along with strengthening strategic partnerships with the Commonwealth. A challenge will be to translate such relationships into practical projects and activities. Similarly, collaborations with business and higher education can be strengthened.

Recommendation 7.4 sets out the proposed approach, focusing on the relationships with the Australian Government's research agencies.

Recommendation 7.4: Strategic relationships, infrastructure and collaboration

As part of the state's approach for increasing the amount, quality and contribution from research and development in South Australia, the Commission recommends the South Australian Government builds enduring strategic partnerships with major Australian Government research agencies to:

- leverage the significant Australian Government investment in intramural research in South Australia, especially DST and CSIRO. With respect to CSIRO, further develop the work program with and reporting process with senior staff responsible for CSIRO's SA operations. With respect to DST, noting the relationships of universities with DST and DST's approach to partnerships (including through the DISP arrangements), support their extension to other research providers and the private sector in SA.
- build nationally/globally significant research scale and impact in areas that attract long term Australian Government intramural support;
- maximise alignment between national research and innovation priorities and the state's economic development goals, including in the alignment of state and Australian Government programs (following a review state policies and programs to identify opportunities for state programs to complement those of the Australian Government that are available to SA business); and
- develop and execute a plan to increase Australian Government investment research infrastructure located in South Australia as part of the EXCITE strategy and the state's strategic plan for research and development proposed in Recommendation 7.1.

The state has a significant portfolio of research infrastructure assets. Chapter 5 includes a recommendation to establish a register of state infrastructure assets that is regularly updated. This action would complement the South Australian 2030 Horizon Major Research Infrastructure and Technology Plan identified in the EXCITE strategy.

A substantial part of the investment infrastructure has been made by successive SA governments in research and innovation precincts. The benefits to date are imprecise at best

and the Commission has been unable to reach an informed view on the net benefits to the state from the more established precincts. The Commission notes that the EXCITE strategy commits the South Australian Government to "work with other major co-investors on the strategic and governance framework required to deliver the metrics of success for each of the existing innovation districts and neighbourhoods" (EXCITE Strategy, p27). This is an urgent priority.

Recommendation 7.5 sets out the Commission's approach to raising the return from existing innovation precincts.

Recommendation 7.5: Maximise the net benefit to the state from research and innovation precincts

To maximise the net benefit to the state from its significant investment in science and innovation precincts, and noting governance structures recently established for them, The Commission recommends that the South Australian Government:

- following the proposal in EXCITE, ensures that each Innovation District/Neighbourhood has a strong governance structure together with a suite of 'metrics of success'.
- emphasizes the promotion of research and development and collaboration among participants in the precinct including universities, businesses and state agencies, including through the application of new governance structures;
- ensures research, development and innovation precincts have clear objectives, ongoing performance measures and regular reviews as part of managing the state's research assets to optimise their value to the state;
- measures the benefits and costs of its investment, particularly in relation to its impact on additional research and development; and
- reviews existing measures which are designed to promote relationships between business and research providers which take account of their complementarity with precinct operations.

Using government procurement

In a smaller state like South Australia, the state government is one of the largest purchasers of goods and services. There are various linkages with research. One is direct, when the state deliberately seeks research to be undertaken in order to solve a policy problem or provide new services. This case is led from the 'top down' in the process of purchasing. There are other opportunities that may arise from 'bottom up', where providers have ideas about new ways of undertaken existing activities at greater efficiency or effectiveness, but which may require some research to prove the concept. There is also an opportunity which lies between these two extremes, in which officials may have a concept of a new opportunity but one which lacks the specificity that allows it to be incorporated into the regular procurement process, and one which providers have not yet considered because of their lack of familiarity with the context in government. These opportunities are worth consideration, but they involve different mechanisms.

The first is relatively easy to manage in the regular procurement process. However, success in not only finding a solution but also in engaging local provides is not straightforward. It is facilitated by providing information on the future needs and procurement plans of agencies; enabling agencies to engage with potential suppliers of innovative and cutting-edge solutions; and obliging agencies to be adequately informed about the availability of local capability. It also aims to remove impediments to participation in procurement by local research groups, including their international networks, issues in relation to which were identified in the procurement inquiry.

The second bottom-up process demands a different setting. It has similarities with the process of unsolicited bids in procurement or planning processes, which depends on an openness to proposals and transparency in their treatment. Success also depends on the same factors as the first item, in terms of access to and official familiarity with local providers and their familiarity with government priorities.

The government has recently adopted a mechanism with respect to the third channel, which is the Go2gov program. The Commission welcomes the initiation of this program and expects that it too would be captured in the program evaluations to be undertaken according to Recommendation 7.3. In particular, the Commission recommends benchmarking the SA program against similar programs in the US and checking the complementarity of the SA program with a similar program managed at national level (the Business Research and Innovation Initiative).

Taking up these approaches does not modify the Commission's previously stated position about ensuring that the state's procurement encourages 'match fit' businesses that are competitive both in the state and in external markets. Rather, it is focused on addressing barriers to innovation, including providing information on the future needs and procurement plans of agencies: enabling agencies to engage with potential suppliers of innovative and cutting-edge solutions; and obliging agencies to be adequately informed about the availability of local capability. It also aims to remove impediments to participation in procurement by local research groups, including their international networks.

The common elements of these proposals are captured in Recommendation 7.6.

Recommendation 7.6: Support associated with government procurement

To encourage research activity associated with the South Australian Government's procurement activities the Commission recommends that the South Australian Government require each relevant agency to:

- facilitate research which is associated with government procurement, including by:
    - developing information on local research and development capability in universities, other research institutions and businesses;
    - making public forward procurement needs that require significant different or innovative solutions compared with the past; and
    - establishing forums in which both items can be discussed.

- set tender terms that ameliorate biases against local research groups, for example, by allowing new groups to compete based on expertise rather than years of experience; and
- in program evaluations in these areas, benchmark local programs against comparable international programs, and check for opportunities to align with and add value in the local operation of Australian Government programs.

Research leadership

The Commission identified several concerns regarding the state's research workforce, especially succession risks in research leadership in the higher education sector. Based on submissions from public universities, retention of research leaders and growing the next generation of top leadership is a challenge. This is consistent with the level of interstate migration in the age range associated with this group. It is also evident in lack of success in the awards of larger research grants (e.g. through the ARC Centres of Excellence program).

The Commission notes that a small fraction of the state's research workforce is directly employed by the state government (mainly in the Local Health Networks and SARDI). Most researchers are employed by other organisations, many of whom the state government cannot influence. The Commission recommends actions that the government could take, through the establishment of the Chief Advisor, to improve R&D leadership in the state and strengthen the research workforce.

Recommendation 7.7 Research leadership and workforce

To maintain and grow the capability of the state's research workforce to underpin the proposed state's strategy for research, development and innovation, the Chief Adviser:

- advise the Minister on the adequacy of the state's research workforce, including the quality and depth of the research leadership in the areas bearing on the state's research, development and innovation strategy;
- engage with, and advise, relevant Chief Executives about the research workforce in their agencies, with particular attention to the research leadership and its relevance to the strategic plan; and
- engage with universities and research institutions to encourage them to report on their strategies for management on the matters of research leadership and the professional development of their research workforces. This may provide the basis for support from the SA Government to recruit key talent.

7.3 Conclusion

The Commission was tasked to recommend actions the government can take to: increase the output and productivity of South Australian-based publicly funded R&D; increase South Australian based private sector R&D; and in so doing increase the State's share of Australian Government funding for research and the State's rate of economic growth.

This report has avoided the simple response of recommending increased spending by the SA Government, although the Commission considers it likely that more investment by the

government will be needed. The better response, in the Commission's view, is to significantly focus on lifting the contribution to the state from R&D by taking a strategic, evidence-based and highly accountable approach and translating its requirements into a more focused and strengthened architecture for the government's R&D activities. Those activities include the government's spending on R&D and related measures such as procurement; actively managing and shaping its portfolio of research infrastructure assets in accordance with evaluation evidence and a strategic plan for research infrastructure assets; and growing key collaborations and relationships.

The Commission considers that this approach will ensure the state can optimise the efficiency and effectiveness of its choices, while providing the evidence to decide the scale.

Appendices

Appendix 1: Submissions in response to the Research and Development draft report to support the final report

Organisation name	Submission number
APR.Intern	FR1
Flinders University	FR2
One World LED	FR3
The University of Adelaide	FR4
University of South Australia	FR5
University of South Australia - Future Industries Institute	FR6
University of South Australia - Future Industries Institute (Minerals Processing)	FR7
City of Salisbury (received after final report was completed)	

Appendix 2: Submissions in response to the Research and Development issues paper to support the draft report

Organisation name	Submission number
Australian Academy of Technology and Engineering	DR1
Commonwealth Scientific and Industrial Research Organisation (CSIRO)	DR2
Crop Science Society of SA	DR3
Flinders University	DR4
Goyder Institute for Water Research	DR5
Horticulture Coalition of SA	DR6
Livestock SA	DR7
Marine Fishers Association	DR8
The University of Adelaide	DR9
University of South Australia	DR10

Appendix 3: Assessment of state-based R&D precincts

Key criteria	Key factors	Assessment
Leadership and governance	Establishment of strategic vision and operational model, incorporating stakeholder requirements, and ongoing evaluation and improvement	The evidence provided to the Commission on stakeholder requirements relates to accommodating physical and tenancy requirements rather than strategic or collaborative arrangements. This is an area for improvement.
	The establishment of formal governance structure	Governance structures have been put in place for each precinct; the effectiveness and appropriateness of these structures varies with each precinct. The focus is on operational matters rather than strategic engagement and is an area for improvement. The strategic focus could include more regular measurement of outcomes and sector engagement.
	Clear responsibilities for financing, ownership, operation and upkeep of infrastructure assets within the precinct.	Clear responsibilities for operational matters have been assigned; the responsibilities for the strategic focus of the precincts are not clearly allocated.
	Leverage of funding from stakeholders and national government	Some Australian Government business support programs have been accessed by organisations and businesses in the operational phase of the precincts.
	Linkage to state and national programs and priorities	Formulation of precinct strategies have demonstrably linked to state-based plans at a high level without carrying through to tangible outcomes. The depth of engagement, functional responsibility and allocation of resources to specific outcomes has not occurred to a satisfactory degree. The links to national programs and policies is also an area for improvement.
	Institutional, firm, and non-profit leaders innovating within their own organisation in ways that advance the precinct	No information provided.
	Separation of operation and research focus from other precincts	There is a degree of overlap in the strategic focus of precincts in sectors such as defence, aerospace, information technology and health, implying a degree of overlap in resources applied in areas of research strength.
Capacity and suitability	Identification of major research institutions within the region	The location of the precincts has always been anchored to one or more universities.
	Identification of the industry clusters and their research capabilities	The identification of sectors for targeting at precincts occurred at the planning stage of each precinct. The relationship between industry and research capabilities was

Key criteria	Key factors	Assessment
		documented for the Thebarton precinct but not others.
	Development of research strategies (by product or technology stream) and/or social theme	This is an area of weakness across all precincts with little evidence presented to the Commission of strategies or activities focussing on themes.
	Identification of business types (mature vs startup) and tenants business capabilities (research strengths, collaboration)	There has been a strong focus on startups and their growth in precincts; an area for improvement is the level of support for and transition of startups to established businesses.
Commercial anchors and collaboration	Match between research strengths of anchor institutions and industry clusters	This is difficult to assess based on the information provided to the Commission.
	Implementation and use of commercialisation mechanisms amongst precinct participants	Commercialisation mechanisms have been the product of university or state government initiatives and programs but have not been established for the purpose of the precinct (or exclusive use of tenants).
	Size and scope for entrepreneurship within the region	There is a large amount of business and stakeholder interest during the establishment phase and the initial operation which evaporates over the life of the precincts. The incentives to locate or engage with precincts are temporary and do not last beyond establishment of the business.
	Support for local businesses	Tenant businesses are eligible for state-wide schemes and some tenants have accessed these programs in their startup phase.
	Development of formal and informal connections between research institutions	The quality of the outcomes of collaboration outcomes have proven difficult for precinct operators to demonstrate and therefore requires better measurement of outcomes in the future.
Support services and social infrastructure	Quality of design and access to physical space and public spaces promoting use and engagement by all sectors in the precinct and visitors to the precinct (that promote R&D or innovation outcomes)	The quality of design space has been mixed and has varied with location of the precinct. Some precincts have been designed to be work and collaboration spaces while other precincts have residential components on site or close by.
	Adequate zoning and planning regulations to prevent dis-used spaces and separation of land use, as well as efficient use of land by state governments	The zoning and planning regulations have in the main been patchy with encumbrances providing some limitation to the scope of some precincts at various stages of their development.
	Suitable employment and residential densities to create interaction	While not an intended feature of all precincts, this happens to an adequate extent where appropriate.

Key criteria	Key factors	Assessment
	Adequacy of private innovation spaces, common areas and equipment, accelerators and co-working spaces	This has been identified as an area for improvement by several reviews for individual precincts particularly for use of common areas as a source of collaboration.
	Suitable mix of residential, commercial or public space, amenities, soft infrastructure, activities	There is a suitable mix of land uses; reviews of precinct operations have identified soft infrastructure and amenities as an area for improvement.
	Cultural spaces, close by or in precinct	As above, this has been identified as an area of improvement in terms of the attractiveness of precincts.
Scale and critical mass	Identification of the region's concentrations of industry	There is no indication of what role this information played in the decision and has occurred after the choice of sectors had been made.
	The location of innovation assets	This was undertaken at the appropriate stage providing information on how best to use the assets and as a basis for industry clustering.
	Physical connection of industry and innovation assets in the city or region	There is more scope for industry to more effectively use the cities' innovation assets.
	Level of startups and success rate in region and growth of established businesses over time	The information has been compiled but there is no indication of relation to support strategies or growth strategies of tenant businesses (and any exit or transition arrangements for mature businesses).
Skills	Sufficient numbers of researchers, inventors, entrepreneurs and workers with technical skills in firms	Stakeholders have indicated that for the most part skill gaps have been minimised; the proximity of the universities has been beneficial to recruitment.
	Programs in place to source key personnel	No information.
	Broad opportunity for range of workers and connection to local recruitment programs	No information.
	Connection to policies to improve STEM at schools and support for regional technical training programs	There are no formal programs involving the precincts; however, there are formal programs involving schools and universities.
Information asset infrastructure	Adequacy of ICT infrastructure and high-speed internet	High performance ICT infrastructure is a feature of all precincts.
	Presence of national/state data repositories and data agency services	There are state-based rather than national data services at state government precincts (and a national data node at Waite).

Source: Assessment by SAPC based on information provided by Renewal SA, DPC and DIS

For more information

W: www.sapc.sa.gov.au
E: sapc@sa.gov.au
P: (08) 8226 7828

30 Wakefield Street
Adelaide SA 5000