South Australian Productivity Commission

Draft report

# Research and Development Inquiry

**9 October 2020**

Government of South Australia

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# 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.

The 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

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# Key messages

The Commission was tasked to report on R&D activity in South Australia and recommend actions to increase the output and productivity of state-based publicly funded R&D; increase private sector R&D; and increase the state's share of Australian Government funding for research and rate of economic growth.

This report focuses on R&D; the translation to growth will be addressed in the final report.

For more than twenty years South Australian governments have policies and programs to foster R&D, including through science and innovation precincts and its own research.

Around $2 billion is spent on R&D annually in South Australia (approximately 1.9 per cent of GSP compared with 1.8 per cent for Australia and second only to Victoria):

- Total business spending is about $800m a year, which is in line with expectations (after allowing for the structure of industry and the size distribution of firms). The propensity of SA firms to spend on R&D is somewhat higher than interstate counterparts.
- The higher education sector's annual spending on research in all fields rose from $500m to over $800m over the decade to 2018. The sector relies heavily on its own funds, which are under pressure from the COVID-19 pandemic and its consequences.
- The Australian Government spends about $300 million directly in SA in forms other than competitive grants, likely through DST and CSIRO. Since 2006-07 intramural expenditure by the Australian Government increased by 12.6 per cent in SA, but 3.2 per cent nationally.
- The Commission estimates the South Australian Government manages around $120m annually on R&D, especially through its agencies. This estimate is a first for the state and the Commission provides six years of data.

In terms of the university research workforce, the number of person years of effort devoted to R&D has fallen over the period 2012 to 2018 from 2,067 to 1,848, compared to an increase in Australia as a whole (23,305 to 24,805) over the same period. The productivity of the research effort matters, particularly the staff time and other inputs used to produce those outputs. Measures are needed to benchmark local performance.

The presence in SA of DST and CSIRO are important, especially in considering the strategic plans of DST and CSIRO where there appear to be significant opportunities for capturing local benefits.

The state policy mix has changed little over the past two decades. A churn in policies is also evident, with a tendency for programs to be replaced by more current or topical approaches. Rigorous evaluation does not appear to have been a strong point. Much of the information on precincts that the Commission has obtained lacks data on their costs and more importantly their benefits.

The Commission notes that, in terms of a principle-based approach, policy is generally tightly targeted in terms of users of new technology or the technologies themselves. A more customised, open and contested regime seems likely to add value.

Despite the continuing relatively high level of R&D activity in the state, the Commission can see little association between this activity and its current selection of performance indicators.

The Commission sees merit in a purposeful framework for policy design (including principles, purpose and tools), data on actions and evaluating outcomes and performance.

The Commission proposes six principles for lifting the productivity and allocative efficiency of the state's R&D policies and programs and sets out three architecture options for discussion. In all cases independent review of performance, regular consideration of the opportunity costs of activities and a focus on people are essential.

# Executive summary

### The Commission's task

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.

In this draft report, the primary focus is on increasing the output and productivity of research. Further discussion on the translation to growth will be provided in the final report. The Commission pays some attention to the innovation system, and the current work on these topics by other agencies, the Chief Scientist and her office in particular.

The task called for a wide-ranging investigation eventually leading to the best recommendations to the South Australian Government that the Commission can make on the evidence put to it.

### Income growth, productivity and R&D

Income growth contributes to both welfare and equity ambitions and raises the average level of wellbeing in the community. It also generates a greater capacity for governments, including at state level, to be responsive to community expectations and to meet new challenges.

A fundamental driver of income growth is the productivity with which natural resources, labour and capital are used in the production of goods and services. In that respect, SA faces a major challenge. The Commission finds that productivity generally has been stable for more than a decade, and that capital productivity has fallen alarmingly over this period in South Australia.

While several factors drive productivity performance, the literature reviewed by the Commission indicates that research likely plays a role. That link is not easy to identify. Research is connected to application and thereby to productivity growth by complex innovation systems, that leads to new and improved products, services and processes.

### Spending and performance – an overview

Overall, there is a substantial amount of research activity in South Australia each year. The Commission estimates this to be of the order of $2 billion (or approximately 1.9 per cent of GSP compared with 1.8 per cent for Australia as a whole). This scale of expenditure relative to GSP is second only to Victoria (section 3.2).

Business, government and the higher education sector are all active in R&D. Figure EX1 shows the comparative spending by Australian jurisdictions relative to the size of their economies. Figure EX2 shows R&D spending in South Australia by higher education institutions, the Australian Government, the State government and business. The Australian Government share and the university share in South Australia are both high (section 3.2).

*Figure EX1: Total spending on R&D as a percentage of GSP by state*

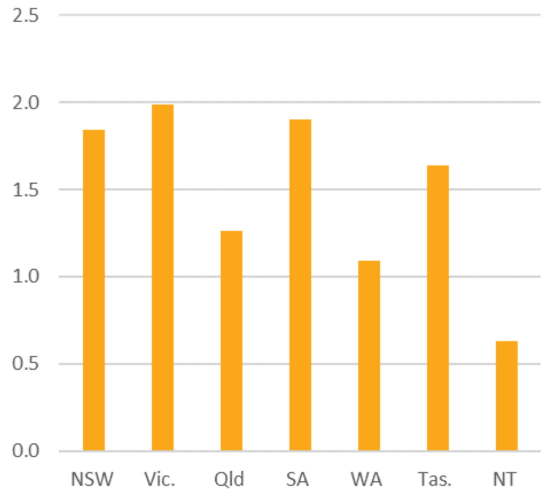
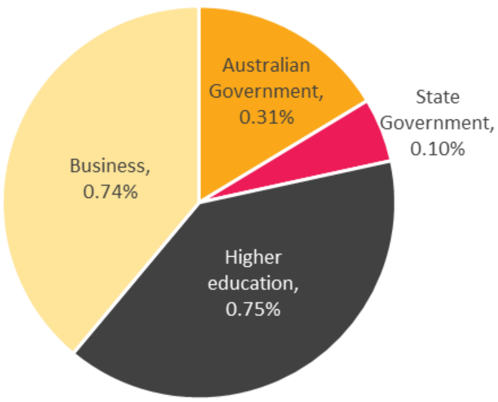



*Figure EX2: Total spending on R&D by sector in SA*




*Source: ABS 8109.0, ABS 8111.0, ABS 8104.0.*

The Commission chose selected performance indicators for the research system which are discussed in Chapter 4. They include measures of:

- activity, such as grant income and business and university spending;
- IP capital formation;
- outputs, such as those linked to basic research and their comparative international standing, and to patents;
- competitive performance in Australian Government competitive research grant programs; and
- the extent of industry and cross-institutional collaborations in the organisation of research.

Table EX1 shows that while research and development in South Australia has some strengths, some indicators show a flat performance, and weaknesses are evident in other areas. For example, Australian Government intramural expenditure in SA is trending up while competitive grants are trending down; and the state's share of patents has been relatively flat over the past ten years after an initial sharp decline.

*Table EX1: Change in 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 ($m)** | 2018-19 | 340 | 308 | |
| **Higher education expenditure on R&D ($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 | |
| **Business expenditure on R&D ($m)** | 2017-18 | 798 | 948 | |
| **No. publications in the top 1% of citations** | 2019 | 209 | 70 | |
| **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 | |
| **No. patent applications** | 2019 | 444 | 605 | |
| **SA share of patent applications (%)** | 2019 | 5.2 | 6.2 | |

[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*

This framework is instructive but incomplete. While their application may not be immediate, research outputs accumulate for later use. The likelihood of finding value in the accumulated research outputs is greater when it incorporates high quality research, measured by global benchmarks.

### Business sector

The research performance by business in SA appears to be in line with expectations, given the structure of industry and the size distribution of firms in the state. The propensity of SA firms to spend on R&D is relatively high but the state's overall share of business expenditure on R&D remains relatively small. Businesses in SA spend about $800m a year on R&D – this is further discussed in section 3.2.4. Despite this effort, patent performance in SA is declining at roughly the same rate as other states. The share of venture capital funds which comes to South Australia is very low at 1.1 per cent of the national total of new and follow-on investment in 2018-19. Venture capital is further considered in section 5.2.2.

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. As stated above, this is an issue common to all Australian states and SA has an opportunity to lead the change in the design of these relationships. Additional assessment of collaboration appears in section 6.2.

An important consideration in this respect; however, is the alignment of areas of research strength on the one hand and industry structure on the other. This is likely to be a two-way relationship. Strong research performance may lead to the evolution of industry structure, but at the same time research that is aligned to local industry concentrations is ultimately likely to be more productive in its impact on downstream jobs and the South Australian economy.

A framework for making informed choices among the sectoral priorities in research is important and, in the Commission's view, is a current gap in South Australia's policy framework. Despite extensive research and consultation, there is little evidence of the existence of this type of framework in SA public policy.

The Commission notes that in this context there is always a question about the benefit of investment by the community in research, since not all the benefits are captured locally (also flowing to the rest of the country and the rest of the world). However, that 'street' carries two-way traffic. The presence of high-quality research groups assists in the translation of research from the rest of the world into local practice, including through education and training. For instance, in this report, attention is given to the international and domestic evidence on the value of placing PhD graduates into business. The Commission considers that deeper business engagement into what, and how local research is undertaken can add to the scale, productivity and quality of that effort. It can also facilitate its translation, help capture value in local conditions and provide some 'first mover' advantages.

Another consideration is the timeframes involved in R&D. Generally, there are long lags from basic research to application. Studies in the agriculture sector for example find lags of decades. Consultations pointed to the current strength in some digital technology areas being based on research done decades ago. This situation has implications for the origins of business growth. The Commission recognises that there is, clearly, opportunity to build brand new businesses out of local research endeavours. Some important examples exist and there is scope for a contribution to growth through this channel. But it is not a plausible scenario, in the Commission's view, to rely on growth in SA through this channel. This outcome will be protracted, given the lags involved. And a high-performing research sector may encourage existing businesses to grow or locate some of their operations in South Australia.

In the Commission's view business investment is more likely to be attracted when the local research system is performing well. These investments are also likely to involve the movement of people, in staff and in management roles. Whether the investment proceeds will then also depend on factors that influence people mobility. Research reviewed by the Commission stresses the importance of the quality of urban amenities.

**Higher education sector**

The higher education sector has spent a substantial amount on research in all fields, with annual expenditure increasing from $500 million to $800 million over the decade to 2018.

This expenditure is funded from a variety of sources, especially competitive grants and the universities' own funds. Higher education expenditure is detailed in section 3.2.3.

A central issue in this inquiry is the quantum and share of funding the state receives via competitive grants. The Commission notes that total ARC competitive grants are lower than they were in 2014 both nationally and in SA. This is compounded by the fact that the state's share in ARC competitive grant funding has also been falling (see Table 3.6). This is a matter of concern because it is a relatively large source of research funding in South Australia.

The Commission also notes the reliance of the higher education sector on its own funds to undertake research, which occurs via teaching cross-subsidies. Noting this share of funding is also relatively low in South Australia, the Commission remains concerned about the uncertainty associated with this funding source, because of the implications from the response to the COVID-19 pandemic for cross border movement of students. This situation is a significant weakness in research funding nationally. 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 activity in the local research system.

High level indicators of higher education research performance are outputs (usually measured by publications) and their quality. The Commission finds that with respect to the latter, several fields perform at global levels. However, the scale, measured by staff, of some of these areas is relatively small, leading to a concern about the sustainability of performance.

This state-wide picture of higher education research shows a high concentration in the field of health and medical research (HMR). South Australia is not an outlier in this respect compared to the rest of Australia, given policy priorities and resources from the Australian Government. That said, the state is an outlier in the share of the national research workforce in HMR, which is relatively high. The SAPC in the draft report of a concurrent inquiry into that sector has separately considered the delivery of research in this field in SA and its productivity. The final report into this inquiry will incorporate the findings, conclusions and recommendations of the HMR inquiry. Other fields in which SA shows a relatively high level of concentration include biological sciences and agriculture and veterinary sciences (see Figure 4.10).

Higher Education Workforce

With respect to inputs to the research process, the Commission has also examined workforce data.

In terms of the research workforce, the number of person years of effort devoted to R&D has fallen over the years 2012-2018 from 2,067 to 1,848, compared to an increase in Australia as a whole (23,305 to 24,805) over the same period. Using ERA headcount data, staff numbers increased in SA over the same time, which implies the use of more part time staff in research and/or more time allocated to teaching or other duties. The Commission is interested in views on the impact of the declining workforce effort devoted to R&D activity in the higher education sector, noting the different degrees of labour intensity in research across fields. Section 6.1.6 of this report expands on research workforce findings.

The Commission is concerned about the composition of the research workforce, especially succession risks in the 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 the lack of success in the awards of larger research grants, for example, centres of excellence. Research in the field of agriculture may be an important example of these issues; it continues to show high performance by most indicators, but the Commission has a question about whether it is now vulnerable to the loss of 'stars'.

As noted, assessments of higher education research performance often consider indicators such as publications or citations. But the productivity of the research efforts also matters, particularly the staff time and other inputs used to produce those outputs. Not all outputs are of equal value in the long run, and some adjustment for this reason is useful. Proxies for value are commonly used, such as the quality of the outputs, measured by the extent of the citations of publications. Taking these points into account, the Commission sees merit in developing measures of productivity for the research sector and using them to benchmark local performance.

Such work also supports assessments of the international competitiveness of various fields of research, based on indicators of productivity and scale that can inform investment decisions.

The Commission has commissioned work on this topic as part of this inquiry. Early results are reported here, based on comparisons of workforce concentration with relative output shares. Some fields of research seem to produce a relatively high share of output given their share of input (e.g. Mathematical Sciences, Physical Sciences and Environmental Sciences); however, there are other explanations of this outcome which the Commission is exploring. The intention is also to benchmark the performance of SA with that of other states.

Data on collaborations in research (measured by the extent of co-authorship) are available in detail for the higher education sector. The Commission has focussed on STEMM fields of research and they show that in SA several fields show a relatively high degree of collaboration with authors outside the state. This adds to the productivity of the research effort in SA, and also generally its contribution to higher quality ratings. There are a large number of studies which find a positive association of international collaboration with research quality, in terms of the extent of citations; and impact, in terms of problem solving.

The Commission also compiled data on publications by different quality indicators. They include the share of papers from South Australia that are included in the top 1 per cent and the top 10 per cent of papers cited world-wide. Generally, these shares have a high association with each other but in some cases the top 10 per cent share is much lower than the share in the top 1 per cent. This may be an indicator of limited depth of talent in local research in this field and seeks further commentary on this view. Research quality and quantity is discussed in section 4.2.4.

**State government**

The state government has implemented policies and programs on research and development for at least two decades. The policy mix includes in-house spending - including forms of procurement, grant programs, precinct investments and other activities promoting cooperation and collaboration among various research organisations. The state also owns significant research assets. These issues are covered in section 2.1.2.

State government expenditure on R&D is a key element of its policy mix. One component of that spending is allocated to its agencies, including the research portfolios of DHW, PIRSA, SA Water, DIS and DEM. It has also funded specialist research groups, including SARDI, BioSA (until recently) and SAHMRI among others.

The Commission has, in a first for the state, compiled estimates of the state government's spending on research and development over the past six years. The state manages a significant amount of spending, especially through its agencies, in the order of $120 million annually. A significant portion of this spending is funded from the state budget with the balance coming from Australian Government agencies, including rural research and development corporations. Levels and patterns of state government R&D expenditure appear in section 3.2.2.

These data are not readily available. That the Commission had to undertake this task reflects the way research and development has been considered and managed from a policy perspective, and a lack of strategic treatment of research spending over the past two decades notwithstanding stated policy priorities and objectives.

Taking a long view, as presented in Figure 2.1 the Commission concludes the policy mix has changed little over the past decade. Policies are generally highly targeted and little activity is open to contest.

**Australian Government**

The Australian Government spends a relatively large amount in SA in forms other than competitive grants. Its direct spending is about $300 million a year. From 2006-07 intramural expenditure by the Australian Government increased by 12.6 per cent in SA and 3.2 per cent nationally (see section 3.1.1).

The presence of DST (fourth highest expenditure on R&D amongst Commonwealth government portfolios) and the interaction with CSIRO (fifth largest expenditure on R&D amongst Commonwealth portfolios) are, in the Commission's view, particularly important. Considering the strategic plans of DST and CSIRO, there appear to be significant opportunities for capturing local benefits of their research.

CSIRO is looking for new partnerships in SA. DST has a new strategic plan which includes the objectives of focussing on larger programs supporting new defence strategic priorities and increasing scale by partnering with national science and technology enterprises and international partners.

The Commission considers it is important for the state to address impediments and missing links to strengthen the role of Australian Government agencies in the local R&D system.

**South Australia Government policy – a twenty-year view**

As part of its inquiry, the Commission examined SA government policy over the past two decades. The Commission considered the impact on research of several research programs not related to spending directly on research. The Commission identified the objectives of these programs and tried to compare them with outcomes, using Commission data or using external reviews by others. The overall picture is limited based on the information the Commission has received to date.

The State Government contributes to research activity through its own research spending and policy and program actions by its agencies. The contribution of some these agencies has been significant, SARDI is an important example. But questions remain including whether the management of that research has crowded out other providers, whether that research could be organised in other collaborative ways, and whether such reforms would increase overall research activity.

In particular, the Commission is assessing the effectiveness of precinct projects, such as Tonsley, which represent a substantial investment of state funding over the past two decades. A qualitative assessment has been completed and, in the lead-up to the final report, the Commission will attempt to gather sufficient data for a more quantitative assessment will also be undertaken.

To assess the impact of precincts, the starting point is to understand their purpose. Precincts are directed to several purposes, of which stimulating research is one and innovation (not the subject of this inquiry) is another. The Commission considers that a greater likelihood of success in R&D and innovation depends on the specification of the objectives and governance structures. Better returns are possible, through better cooperation of organisations present at the precinct and those located elsewhere who might benefit from deeper engagement.

Recent developments raise more fundamental questions about the precinct strategy. In many studies, it has been argued that proximity matters for the sharing of ideas and knowledge. The Commission notes that much of the research underpinning this advice was undertaken before the growth of fast high bandwidth digital communication and, of course, before the COVID-19 pandemic and the experience of the shift to remote working. Physical proximity was once thought to be critical to human relationship identification and development, but this may be changing.

Moreover, the Commission notes that much of the information on precincts to which it has access lacks data on their costs and their benefits. This situation greatly constrains the capacity to understand the value of such investments and stands in sharp contrast to a recent study released by the NSW Office of the Chief Scientist and Engineer[1].

The Commission accepts that there is value in proximity but the cost of generating that outcome also matters. If virtual precincts and virtual collaboration are now becoming more culturally acceptable, viable and potentially normal amongst modern knowledge workers, then the cost of virtual compared with physical precincts must now be part of the assessment of precincts.

This leads to the bigger issue of the choice between investing in infrastructure and other alternatives. The question always worth asking is how could the resources be better deployed? One option is to develop higher-performing researchers locally, another is to recruit them into SA. The Commission is open to comments on these options. That said, the Commission remains concerned about a bias to infrastructure, and the lack of a framework with a longer timeframe that considers all options. Infrastructure is considered in section 5.1.

The linkages of policy and performance have also been examined, looking for shifts in research system performance indicators - such as grant income and business expenditure - associated with programs and policy. Despite the continuing relatively high level of activity in the state, the Commission can see little association between the two, at least in the current selection of performance indicators. Indeed, more concerning is the decline in some areas of competitive performance, especially in securing Australian Government competitive grants.

[1] Report for the NSW Government Office of the Chief Scientist and Engineer (OCSE) *Impact from NSW OCSE Funded Centres*

Another challenge to assessing the contribution of SA R&D policies to impacts is that they are not the only contributors to R&D performance, since the contribution of the research institutions (including universities) also matters. Their performance (where they are not state agencies) and their arrangements of cooperation or engagement with each other are outside the scope of the inquiry. Of more interest is the program design and the interaction of the state with these external research providers, bilaterally or jointly. In that respect, the Commission finds that despite a number of announcements of good intentions in this respect, there has been little progress or impact.

Several factors mediate the impact of policy on performance, including the state's demography and policy regimes in other fields, including data privacy, and infrastructure.

In summary, the Commission has not yet in general been able to establish significant contributions from South Australian research policy and programs to performance of the R&D system but it notes the role of mediating factors.

The Commission considers the management of the state's policy approach would benefit from a purposeful framework for policy design, performance data on implementation, monitoring of outcomes and program evaluation. There are gaps in all these areas. The Commission will further explore the importance of these factors.

A churn in policy over the past two decades is also evident, with a series of rediscovered 'new things' and new points of focus. Programs tend to have been abandoned and replaced by more current or topical approaches, rather than being appraised and then formally shut down as a result of explicit decisions about their end-of-life.

The Commission concludes that while the state is busy, not many programs are long-lived, and there appears to be a pattern of recycling policies, which suggests there has been limited evaluation of initiatives.

The Commission is also concerned that, in terms of principles, policy is generally tightly targeted in terms of users of new technology or the technologies themselves. Accordingly, policy choices are not sufficiently contested in terms of participation by different research providers, nomination of specific providers and the limited extent of activities, especially funding, that are open to competition.

The Commission considers that given the nature and pace of technological change, a more customised, open and contested regime would add value. Such a regime can be organised in a way that is consistent with the principle of taking a longer-term view both of policy goals and the operation of programs, while not forgetting the value of 'sunset' clauses.

**Principles for performance**

The Commission concludes that:

- the investment in R&D by successive state governments is essential to the state's future performance;
- opportunities are foregone in current circumstances; and
- the existing effort by the SA government can make a greater contribution to R&D performance and productivity by explicitly adopting principles to guide its decision making.

Six principles are proposed:

1. take a state-wide, cross sectoral and 'all-technology' perspective to the state's overall R&D strategy by elevating and consolidating within the structure of government the points of decision making about areas of investment in research, and about the choice of complementary policies
2. seek simplicity in policy design and implementation, including a clarity of purpose, reduction of duplication, and in the setting of targets,
3. embed transparency and accountability for performance by ensuring research programs make clear:
    - the problem being solved;
    - the goals of each policy tool;
    - performance indicators;
    - results achieved, including where relevant to the delivery of government services;
4. where directions are set, make the mechanism for delivery contestable;
5. facilitate collaboration that adds value to locally-provided resources; and
6. use strategies with longer time horizons, organised with critical milestones and a framework for risk management.

These points are elaborated in the following section.

**Path to Performance**

The Commission has concluded that successive state governments have, appropriately, supported a significant amount of R&D activity over many years and this activity could have been, and can be, more effective. While individual programs vary, the broad pattern is that R&D policy and activities generally lack specific quantitative objectives, are complex, duplicate each-other at times and are not regularly and credibly independently assessed. As a result, there is, in the Commission's view, an important, underused opportunity to learn from previous policies and a lack of focus on what matters.

The Commission was asked how to increase the output, productivity and translation of R&D activity in SA. An obvious response is to increase spending on R&D. However, as noted above, the level of spending on R&D in SA is already relatively high. There are other priorities, in the Commission's view, compared to that track.

In particular, there is scope to increase the contribution of the R&D activity already undertaken, by raising its efficiency in two aspects:

1. increasing the productivity of the initiatives undertaken, that is, the level of output compared to the inputs involved (or the technical efficiency of the R&D effort); and
2. reconsidering the allocation of funds across projects and fields to yield a higher return (or the allocative efficiency of the R&D effort).

The application of principles with respect to the design of policy, including simplicity, accountability, and transparency, will contribute to both forms of efficiency, for example by better assessments of performance of projects, leading to lessons learned for future investments and project designs.

The Commission also noted that the majority of SA Government expenditure for R&D remains uncontested. That is, the state either allocates funding to itself to conduct R&D on behalf of industry and the community, or it provides funding directly to particular entities or projects for a predetermined purpose. Very little of this funding is genuinely contested in the market. This limits the extent to which state R&D funding can respond to the impulse of economic activity, and in turn, the extent to which the benefits of new knowledge and technologies can proliferate through the economy. Competitive arrangements allow greater scope for new research partnerships to emerge. The Commission's view is that given the nature of technological change, a greater weighting towards openness and contestability is likely to add value.

The local research system will perform better through cooperation. Examples noted above include the cooperation of local researchers with those in other locations. Another example is the cooperation with Australian Government agencies. Both channels provide important opportunities to add value to expenditure by the state government, and by local institutions. The Commission proposes that the research system performance indicators continue to include items related to collaboration. An explicit strategy for continuing to engage with Commonwealth agencies would also be valuable.

Given the lags inherent between R&D and outcomes, the Commission considers it pays to take a long view to avoid terminating policies and programs prematurely. However, implementation of that approach as state government considers its research expenditure also calls for care to avoid continuing an unproductive activity. A balance between these considerations can be found, for example, through the establishment of gateways, identified in advance, at which decisions can be made to 'go or not go' further. Clearly, taking a long view creates some exposure to risk, that management of which also involves development of a diversified portfolio and risk sharing with other institutions, including research providers.

In summary, contributors to the efficiency of the local R&D system involve the application of principles of simplicity, accountability, and transparency as well as contestability and collaboration, plus the adoption of a longer time horizon in the context of relevant risk management systems.

These observations apply not only to the parts of the local R&D system for which the state government is accountable and its policies and programs; they apply to the state's research institutions that are independent of government. That said, the Commission's terms of reference limit it to making recommendations to the South Australian Government.

Pursuit of this approach to efficiency gains by the government will, in the Commission's view, be better supported by changes to its own R&D system architecture. (By architecture, the Commission refers to the institutions, roles and accountabilities of those involved in shaping, implementing and doing research and supporting those activities.)

Critical to success is the elevation of decision making to provide a view across projects and to permit benchmarking of performance. Decision making at a higher level facilitates coordination and consistency among agencies and programs and the application of a framework of decision making for investment across fields of research.

### Options for a better R&D architecture

There are several possible architectures. The Commission sets out three approaches for discussion as part of moving to the recommendations in its final report. These options are intended to assist in identifying all the issues that need to be addressed in settling on a more robust, strategically framed and accountable whole of government approach to the state's R&D activities to lift their productivity.

The Commission is not proposing any specific option as the best way forward at this point.

### Option 1: Minister responsible for R&D strategy and performance

This approach would have a Minister accountable for the state's R&D strategy. This would establish R&D targets that are simple and quantitative, noting this draft report has identified some areas where targets could be set. It would be backed up by a team to support the achievement of targets, simplifying the governance arrangements and removing duplication now in government R&D policy, activity governance and administration. This work would be underpinned by consolidated information on the amount, location and performance of SA R&D activity.

The idea of a Minister for R&D has precedent in Australia noting that NSW has a Minister for Health and Medical Research.

South Australia already has a Minister for Innovation and Skills who is responsible for workforce training and skills, innovation and entrepreneurship, science and information economy, apprenticeships and traineeships, creative industries and skilled migration. These responsibilities clearly have strong links to R&D. Option 1 contemplates a complementary focus on R&D as the engine room for innovation.

### Option 2: An independent advisory body

This option contemplates a special purpose expert, independent advisory body to advise on the state's overall R&D strategy and performance. This would need to take into account current advisory roles like that of the Premier's Science and Innovation Council, but its intended scope would be broader. It would provide advice to government, among other matters, on improving the allocative efficiency and apply a distributed approach with a common framework and public reporting on technical efficiency matters. To be effective it would need the same consolidated information identified in Option 1 and to be supported by a team.

### Option 3: A strategic R&D committee of senior officials

This option would bring together, at a minimum, the most senior government officials who are accountable for R&D and R&D policy, including the SA Chief Scientist, and the key R&D executives in government. It could provide similar advice as in option 2 and be tasked with developing a whole of government R&D strategy, along with transparent accountability for performance (including targets and measures) in their own areas.

The same consolidated information as in Options 1 and 2 would be essential to underpin Option 3.

The Commission notes that the three options are not mutually incompatible, and a better option might combine elements of all three.

## Concluding thoughts

The Commission concludes with three key elements that it considers essential to be incorporated in the management of all these options, or any feasible alternative that is identified during consultation.

1. Independent review of performance

   The implementation of all options will depend not only on the adoption of a set of performance measures for the research system, but also on the consistent collection of data for those measures across all agencies and research system participants. There would be annual measurement and reporting of SA performance against targets, by an independent group. This information would also include an accurate register of research assets.

2. Regular consideration of opportunity costs

   While the opportunity remains in every year in the state budget process to argue for greater funding to allow delivery of the targets, the overall process would be driven by an innovative philosophy that seeks savings and efficiencies (e.g. pursuing cheap and flexible virtual precincts rather than costly physical precincts) and sets expectations for research excellence. These savings can then be applied to more productive use. In effect, there is continuing cost/benefit analysis of current activities against a range of policy targets and options.

3. A focus on people

   The Commission found that the presence of high performing researchers is necessary for high quality R&D, more so than buildings, governance committees or administrators. The Commission proposes that attention shifts at the most senior levels of government towards a focus on researchers and their performance.

The Commission looks forward to further consultation with stakeholders and interested parties to help it develop its final recommendations to the South Australian Government. Contributions and expert views, especially where supported by evidence, are welcome.

# Summary of information requests and recommendation

## Information request 2.1

The Commission seeks further information on R&D policy and programs in South Australia:

- What else can we learn from the state's previous R&D initiatives and economic strategies?
- Was the use of economy-wide targets under the SASP and STI[10] an effective way of compelling change and measuring performance?
- Are there any other initiatives or institutions that the Commission should consider in understanding the R&D system and performance in SA? How should these be improved?

## Information request 3.1

The Commission seeks further information on the following issues:

- Is the Commission's characterisation of R&D expenditure in South Australia accurate?
- Are there any sources of funding for R&D or areas of expenditure that require further examination?
- What other sources of data are available that have not been used by the Commission?
- Why does South Australia receive such a small portion of private non-profit R&D?

## Information request 4.1

The Commission invites feedback from stakeholders on possible measures of South Australia's performance in R&D, including:

- has the Commission adequately characterised the performance of South Australia's R&D performance, and what could be improved?
- what measures of R&D performance provide meaningful insight into R&D performance?
- how can productivity of R&D be measured and meaningfully interpreted?

## Information request 5.1

The Commission invites feedback from stakeholders on strategies for the South Australian Government to improve its engagement and alignment of priorities with the Australian Government and to leverage increased funding for R&D infrastructure assets supporting the needs of business.

## Information request 5.2

The Commission invites feedback from stakeholders on the operation for South Australia's innovation and science precincts with regard to:

- ensuring that there is an appropriate offering of business capability services and whether a much sharper focus on industry development is appropriate;
- the scope to facilitate better coordination of the strategies and activities of the precincts; and
- the scope to support increased collaboration activities between universities and businesses at the precincts.

## Information request 6.1

The Commission seeks stakeholder views on the value of:

- enhancements to the platform to assist universities to advertise their funded postgraduate scholarships locally and internationally in one central location;
- incentives for industry-linked PhDs to help increase the education levels of the workforce as well as improve and foster linkages between industry and universities for R&D;
- growing support programs that extend beyond PhD scholarships, including support for postdoctoral studies and support for existing workers to undertake postgraduate studies;
- enhanced support in the future to take up and engage graduate researchers as well as enable employees with research skills within business to collaborate and interact with the research community;
- facilitating the placement of PhD graduates in projects and activities of strategic value to the state; and
- the state government, as a major employer, supporting more research skill positions with the public sector.

## Information request 6.2

Participants are invited to provide their views on the scale and type of collaboration mechanisms, either discussed in this section or preferably based on experience and insight, best suited to the South Australian context.

## Information request 6.3

The Commission invites insights from stakeholders based on their experience and knowledge on:

- the type of intermediary organisations and responsibilities that are appropriate considering the state’s structural and institutional characteristics; and
- whether intermediary organisations should have an industrial focus and be specialised in specific technological niches or build new collaborations across disciplinary and geographical boundaries.

## Recommendation 5.1: Central information register of R&D infrastructure

The Commission recommends that the Office for the Chief Scientist, in regular cooperation with universities and industry develop, maintain and promote the extent of research and development infrastructure available for use in South Australia (including national infrastructure networks).

# Acronyms

| | |
|---|---|
| ABS | Australian Bureau of Statistics |
| ABSBR | Australian Bureau of Statistics Business Register |
| ACGR | Australian Competitive Grants Register |
| ACIAR | Australian Centre for International Agricultural Research |
| AGRF | Australian Genome Research Facility |
| AGT | Australian Grain Technologies |
| AIML | Australian Institute for Machine Learning |
| ANDS | Australian National Data Service |
| ANSTO | Australian Nuclear Science & Technology Organisation |
| APR | Australian Postgraduate Research |
| APRIL | Australasian Pork Research Institute Limited |
| ARC | Australian Research Council |
| ARDC | Australian Research Data Commons |
| ARENA | Australian Renewable Energy Agency |
| ASBFEO | Australian Small Business and Family Enterprise Ombudsman |
| 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 |
| CDG | Christian Doppler Research Association (Austria) |
| CES | Cooperative Extension Service |
| CoLAB | Collaborative laboratories |
| COVID-19 | Corona virus disease of 2019 |
| CRC | Cooperative Research Centres |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DEM | Department of Energy and Mining |

| | |
|---|---|
| DFEEST | Department of Further Education, Employment, Science and Technology |
| DHW | Department for Health and Wellbeing |
| DIS | Department for Innovation and Skills |
| DMITRE | Department for Manufacturing, Innovation, Trade, Resources and Energy |
| DNA | Deoxyribonucleic acid |
| DST | Defence Science & Technology |
| EDB | Economic Development Board |
| EI | Engagement and Impact |
| ERA | Excellence in Research for Australia |
| FIA | Future Industries Accelerator |
| FIEK | Centres for Higher Education and Industrial Cooperation (Hungary) |
| FTE | full-time equivalent |
| GDP | gross domestic product |
| GSP | Generalised System of Preferences |
| GSSA | Geological Survey of South Australia |
| GUF | general university funds |
| HDR | higher degree by research |
| HERD | Higher education expenditure on Research and Development |
| HES | Higher Education Standards |
| HMR | health and medical research |
| ICC | Innovation & Collaboration Centre |
| ICP | Innovation and Commercial Partners |
| IEP | Industry Engagement Priorities |
| IoT | Internet of Things |
| IP | intellectual property |
| IPPs | Information Privacy Principles |
| IPR | intellectual property rights |
| IT | information technology |
| LIEF | Linkage Infrastructure, Equipment and Facilities |
| MaRS | Medical and Related Sciences |
| MDPP | Medical Devices Partnering Program |
| MFP | multifactor productivity |

| | |
|---|---|
| MIP | Mawson Innovation Precinct |
| MISP | Meat Industry Strategic Plans |
| MRFF | Medical Research Future Fund |
| NBF | National Biologics Facility |
| NCGP | National Competitive Grants Program |
| NCRIS | National Collaborative Research Infrastructure Strategy |
| NeCTAR | National eResearch Collaboration Tools and Resources |
| NHMRC | National Health and Medical Research Council |
| NIFA | National Institute of Food and Agriculture |
| NISA | National Innovation and Science Agenda |
| NVI | New Ventures Institute |
| OECD | Organisation for Economic Co-operation and Development |
| PhD | Doctor of Philosophy |
| PIMC | Primary Industries Ministerial Council |
| PIRSA | Department of Primary Industries and Regions |
| PISA | Programme for International Student Assessment |
| PRI | public research institute |
| PRIF | Premier's Research and Industry Fund program |
| PwC | PricewaterhouseCoopers |
| PYE | person years of effort |
| RCSF | Research, Commercialisation and Start-up Fund |
| R&D | research and development |
| RDC | Research and Development Corporations |
| RD&E | research, development and extension |
| RDS | Research Data Services |
| R&I | Research and Innovation |
| RSP | Research Support Program |
| RSSA | Rural Solutions SA |
| RTO | Research and Technology Organisations |
| RTP | Research Training Program |
| SABRENet | South Australian Broadband Research and Education Network |
| SACFI | South Australian Centre for Innovation |

| | |
|---|---|
| SAES | State Agricultural Experiment Stations |
| SAHMRI | South Australian Health and Medical Research Institute |
| SAPC | South Australian Productivity Commission |
| SARDI | South Australian Research and Development Institute |
| SARIG | South Australian Resources Information Gateway |
| SASP | South Australia's Strategic Plan |
| 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 |
| TNO | Netherlands Organisation for Applied Scientific Research (Netherlands) |
| TRL | technology readiness level |
| UniSA | University of South Australia |
| TMI | Tonsley Manufacturing Innovation |
| UoE | Unit of Evaluation |
| US | United States |
| USA | United States of America |
| USDA | United States Department of Agriculture |
| 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.

Part of the concern by some 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.

In addressing its task, the Commission is required to have regard to the South Australian Government's Growth State initiative and relevant state and national policies.

This inquiry has largely been undertaken during the COVID19 pandemic. The Commission appreciates the efforts of all participants in the inquiry process especially given the extraordinary circumstances.

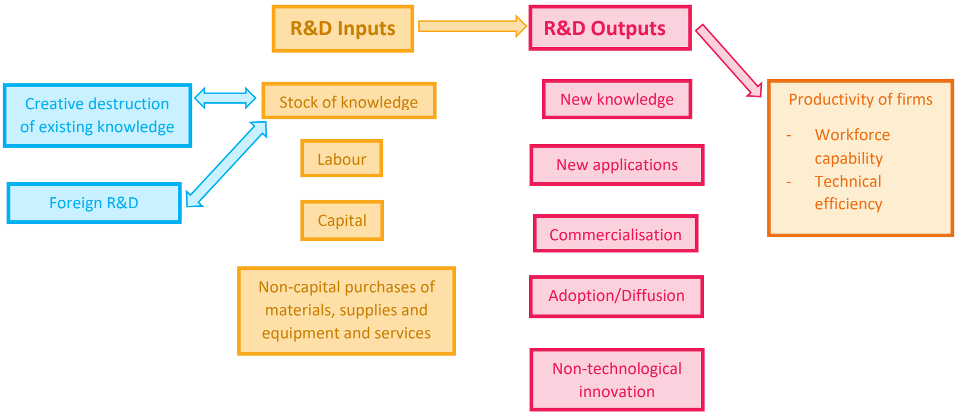
## 1.2 Definition of R&D

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[2].

The scope of measured R&D covers natural sciences, engineering and technology, medical and health sciences, agricultural sciences, social sciences, architecture and design, law and humanities. R&D can have economic, social and environmental relevance and application crossing over several fields.

[2] 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)*

A simplified representation of the system of relationships that direct R&D activity, innovation and spillovers of knowledge is shown in Figure 1.1. The framework illustrates that a critical input to R&D activity is knowledge previously generated within the domestic economy and knowledge generated internationally. There is an ongoing interchange of knowledge replacement and addition with the value and use of various sources of knowledge driving ongoing R&D activity and consequent growth in output.

R&D activity can be broadly viewed as a flow where inputs including finance, people and infrastructure are transformed into outputs such as journal articles or patents, subsequently leading to valuable outcomes such as new knowledge, new or improved products and new or improved processes, all of which contribute to economic growth.

R&D investment, research and development undertaken in the current year continues to benefit both those who undertake it and society at large in future years. R&D is cumulative in nature, which can lead to increasing returns, both in aggregate and for individuals and firms.

Other indirect benefits from research include contributing to public policy making and increasing the skills and adaptability of a tertiary qualified workforce. Another implication of Figure 1.1 is the relationship between R&D and innovation: where the latter involves the translation of the former. R&D is an essential platform for innovation and the relationship between process and product innovation and development of new products is a critical interface for business.

## 1.3 Measurement of research and development

The attributes of R&D create challenges in measurement and analysis. Knowledge is not uniformly distributed and used in an economy. Complementary inputs necessary for results vary across types of activities, industries and regions. Benefits may be realised by entities other than those that carried out the R&D. The benefits are also likely to accrue in locations beside that in which the R&D occurred.

Measuring research or inventive activity through inputs is difficult as the mechanisms that translate inputs into outputs are not well understood. While the respective units of inputs are roughly uniform there is no commonly accepted unit of research or the results of research. Measuring research or inventive activity has also been attempted in terms of its outcome, technological advance and advance in knowledge using indicators such as patents and academic publications.

Several landmark studies over the last 40 years have examined the hypothesis that productivity growth is causally related to expenditure on R&D[3]. This research has enlarged the neo-classical model of economic growth by adding R&D spending as a central determinant alongside productivity, capital accumulation and population growth[4]. The evidence may suggest that sustained economic growth requires the spillover effects, both radical and incremental, created by innovation.

Several authors have developed growth models in which advances in technology, generated by R&D activity, drive additional economic development[5] [6]. Other studies are concerned with measuring the net rate of return or the absolute return on investment in R&D[7] [8].

Attempts to measure the consequences of R&D have relied on a range of methods including case studies, impact analysis, bibliometric analysis, surveys and economic modelling. These methods can be entirely qualitative, entirely quantitative or a combination of both.

Even the most immediate outcomes of research, such as additions to the stock of knowledge, have challenges in their measurement. Accordingly, outputs are often used as proxies, with the choice of these proxies often being driven by data availability. In the higher education sector for example, the most widely used measure of R&D output is publications while in the business sector the number of patents is a common measure.

The attributes of R&D create challenges in measurement and analysis. Knowledge is not uniformly distributed and used in an economy.  Complementary inputs necessary for results vary across types of activities, industries and regions. Benefits may be realised by entities other than those that carried out the R&D. The benefits are also likely to accrue in locations beside that in which the R&D occurred.

To mitigate the risk of these investments, it is essential to have an effective set of gateways and measures to evaluate project performance. This is especially critical in organisations with cultures that are predisposed to avoid the difficult decision to exit an existing underperforming R&D investment. Having clear gateways, effective measures and a strong process will help overcome internal barriers to re-evaluating past decisions.

## 1.4. The economic importance of research and development

Productivity growth matters because it leads output to growth faster than the extent of resources applied to production, which in turn enables incomes to grow in real terms.

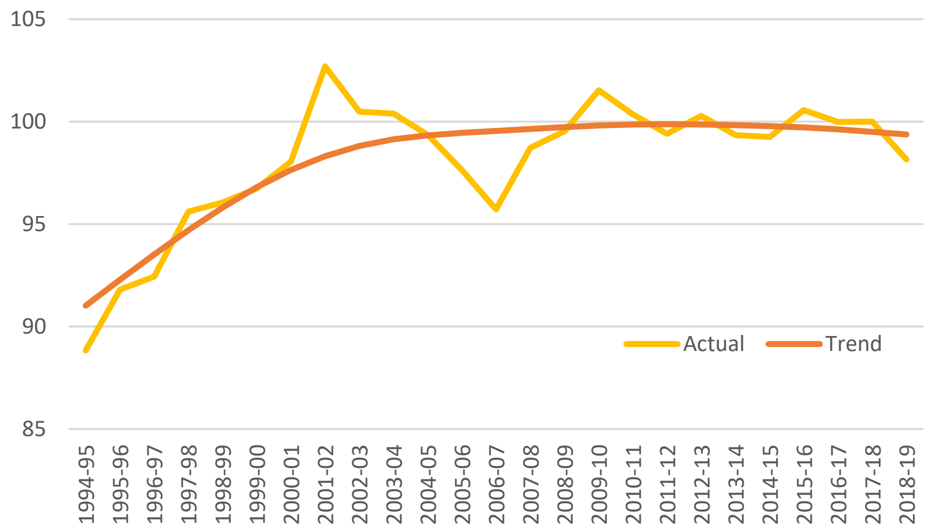
The Commission recently published an analysis of South Australia's productivity performance over the past 25 years.[9]

[3] Zvi Griliches, 'Issues in Assessing the Contribution of R&D to Productivity Growth' (1979) 10(1) *Bell Journal of Economics* 92-116.
[4] Luisa R Blanco, Ji Gu Ji and James Prieger, 'The Impact of Research and Development on Economic Growth and Productivity in the U.S. States' (2016) 82 (3) *Southern Economic Journal*, 914-934.
[5] Paul Romer, 'Increasing Returns and Long-Run Growth' (1986) 94 (5) *Journal of Political Economy*, 1002-1037.
[6] P Howitt and P. Aghion, 'Capital Accumulation and Innovation as Complementary Factors in Long-Run Growth' (1998) 3 *Journal of Economic Growth* 111–130.
[7] P Mohnen, 'New technologies and interindustry spillovers' (1990) 7 *OECD STI Review*, 131-147.
[8] M I Nadiri and S Kim, 'R&D, 'Production Structure and Rates of Return in the U.S., Japanese and Korean Manufacturing Sectors: a Non-Sector Model' (1996) NBER working paper 5506.
[9] SAPC Research Discussion Paper No. 1.

In the period 1994-95 to 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. Overall, MFP stagnated. South Australia experienced a 20 per cent fall in capital productivity from 2001-02 to 2013-14, in line with the decline at the national level. Since then capital productivity at the national level has stabilised while SA's capital productivity has continued to fall.

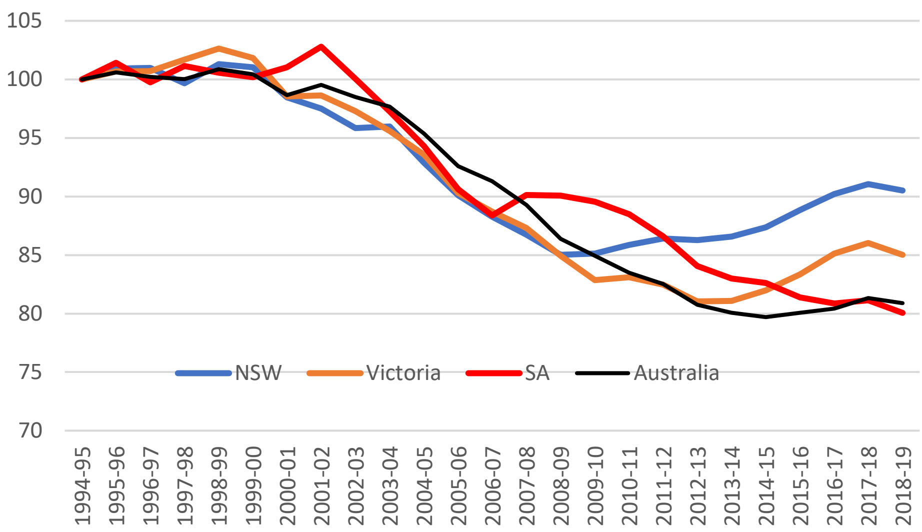
The main contributor to weaker productivity growth at a national level, and affecting South Australia, has been weaker output growth. Output grew at only 1.3 per cent a year between 2003-04 and 2017-18. The performance of South Australian MFP can be seen in Figure 1.2.

*Figure 1.2: 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)*

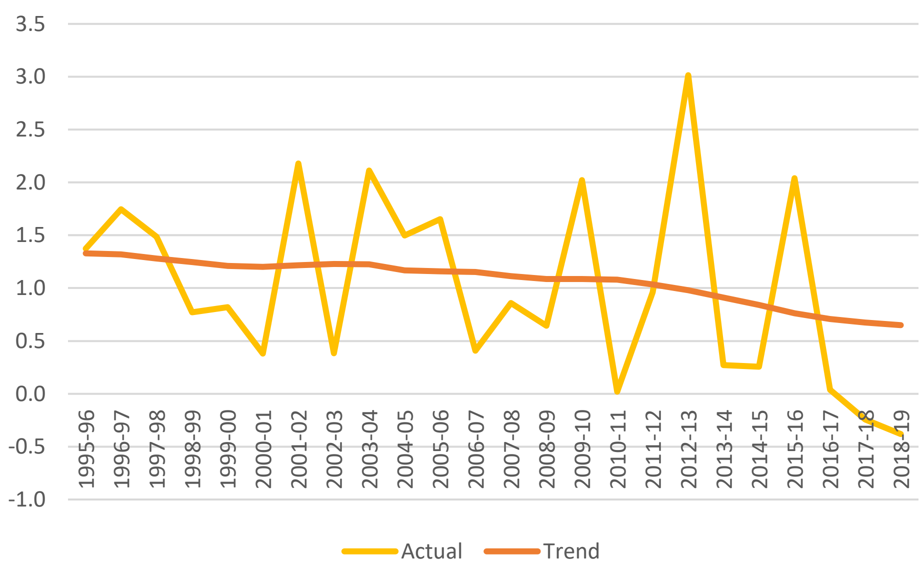
*Figure 1.3: Index of capital productivity performance in Australia and selected states, 1994-95 to 2018-19.*




*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 slower growth in capital than in labour is evident in the analysis of capital deepening (the ratio of capital to labour inputs) shown in Figure 1.4. In the last two financial years, there was a shallowing of capital (or in real terms labour inputs had a lower amount of capital to work with).

*Figure 1.4: Annual rate of change of the capital to labour ratio in the South Australian economy (%)*




*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 literature has shown that R&D-related activities can explain up to 75 per cent of the total factor productivity growth, once externalities are considered. The private returns to R&D are generally found to be positive, and higher than those for physical capital. (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 GDP growth in the OECD over the long-term (OECD Innovation Strategy 2015: An Agenda for Policy Action).

The Commission concludes that stronger R&D performance can be expected to improve economic performance and economic growth. Higher productivity in that R&D effort can be expected to provide higher returns in the form of economic growth and productivity.

## 1.5 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. The following discussion draws from the body of literature that emerged seeking a better understanding of the innovation process and associated R&D policy instruments. 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 more generally in the economy. R&D policy instruments may also have a specific local or regional focus or seek to more broadly influence innovation systems.

### 1.5.1 Direct versus indirect financial assistance

*Direct* financial assistance provides up-front financial support directly to entities to assist with the cost of R&D. It is typically provided in the form of grants and subsidies, but can also include other financial tools, such as loans and equity funding. This is in contrast with *indirect* financial assistance (namely tax concessions), which requires entities to invest in R&D with their own resources before reaping any benefit.

Direct financial assistance is usually provided at the discretion of government agencies, which has the advantage of allowing them to target particular R&D projects. However, providing direct assistance can create problems with:

- rent seeking – entities seeking government resources for their own private benefit regardless of the potential for societal economic gains; or
- lock-in/path dependency – where a government's initial decision to provide direct support creates an obligation or momentum to continue to provide this assistance even when circumstances change.

Indirect assistance through tax concessions can be also be problematic because, as it requires businesses to invest in R&D in the first place, it may not address any particular market failure and simply replace private investment.

### 1.5.2 Supply versus demand-side instruments

Supply-side policy instruments aim to increase the 'supply' and availability of R&D resources in a market. Governments do this either through direct provision — establishing state-based R&D agencies — or by providing funding to other to entities to undertake R&D. Such policy can also focus on increasing the supply of the various inputs to R&D, specifically labour (research professionals and people with specialist skills) and capital (infrastructure and machinery). Demand-side policy instruments try to facilitate the demand for R&D services in markets, and governments can have a substantial influence over market demand through procurement activities. Some of the literature on this topic also relates demand-side policy to policies influencing the wider business environment and the ways that these may incentivise or discourage R&D investment, including sector-specific regulation, standards setting, and intellectual property rights.

### 1.5.3 General versus targeted instruments

General R&D policy instruments aim to have a neutral effect across entities and sectors by providing assistance across-the-board. Such an approach is beneficial in that assistance can be driven by the market and therefore be more likely to support opportunities that will result in business growth (general R&D tax concessions are an example). However, general instruments can increase the likelihood of deadweight loss because assistance is provided indiscriminately regardless of the relative social or economic benefits of each project. Targeted initiatives, on the other hand, can be employed to optimise the social and economic return for R&D, noting that this is very difficult for governments to predict. Targeted instruments, as they usually involve direct assistance, are prone to the same problems of rent seeking and lock-in/path dependency.

### 1.5.4 Place-based and systems-focused instruments

Beyond providing assistance for particular entities, industries or projects, governments also attempt to increase R&D activity by focusing on how the ‘innovation system’ works. These typically have a place-based focus (on localities and regions) and attempt to maximise R&D cooperation between entities in the innovation system, optimising R&D effort and hastening the commercialisation and diffusion of new knowledge. The emphasis on geographic location draws from academic literature and evidence that physical proximity is still an important driver of innovation — because the clustering of enterprises supports locally concentrated labour markets, specialisation in production, and the attraction of specialised buyers and sellers. Clustered enterprises can also enable more efficient ‘matching’ between economic agents (e.g. between employees and employers, financiers and firms looking for funding, firms looking for partners, and buyers and sellers). Innovation and science precincts (discussed in depth in section 5.1) are a clear example of a place-based and systems-focused policy instrument that has proved popular internationally, and indeed, in SA. And while the success factors for precincts have become clearer over the past decade, the literature is yet to provide a body of evidence to show that government-created precincts have a substantial impact.

Other systems-focused instruments include initiatives that:

- facilitate information sharing and collaboration between parties with an interest in R&D (universities, research institutions, businesses, producers and consumers);
- provide networking and brokerage support so that entities can access the skills, expertise, equipment and infrastructure required for R&D projects;
- support interstate and international linkages as well, to attract labour and capital to support local R&D; and
- encourage the diffusion and adaptation of new knowledge and technologies across markets.

Place-based and systems-focused instruments can help reduce the information and transaction costs between entities in a region so that they can engage more effectively in R&D and share in the benefits of knew knowledge and technology.

## 1.6 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 invited submissions in response to a Research and Development issues paper. Submissions could address any of the issues covered in that paper, and/or any other matters relevant to the terms of reference where the Commission's understanding was imperfect. Ten submissions were received in response to the issues paper. This information has greatly assisted the Commission's understanding of all aspects of its task. Appendix 1 contains links to the full list of submissions. In addition, the Commission undertook a wide consultation, including 55 meetings of Commissioners with various stakeholders.

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.

Following the release of the draft report, the Commission will consult further with stakeholders to test and verify the Commission's understanding of the issues, as well as possible recommendations.

## 1.7 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.
- Chapter 3 gives details of R&D funding, 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.
- Chapter 7 delivers final analysis and recommendations.

# 2. Policy environment

Australian and SA governments have a long history of promoting R&D through a wide range of initiatives: providing direct and indirect financial assistance; implementing measures to increase the supply of and demand for R&D among firms and across markets; and introducing initiatives that either fund R&D generally across the economy or target nominated firms, sectors or projects. Specific examples include:

- running public R&D institutions;
- establishing public/private precincts where R&D is undertaken;
- directly funding R&D through grants and subsidies;
- providing indirect funding as tax incentives to businesses investing in R&D; and
- supporting R&D activity in the higher education sector.

Figure 2.1 presents a timeline of R&D-related policy changes introduced by Australian and SA governments over the last four decades, which have helped shape current R&D policy in the state. Successive governments in SA have vigorously 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, which is the subject of a separate inquiry). More recently, the policy focus has expanded to engineering and tech-related industries. The state also has long-standing investments in R&D institutions and science and technology precincts. A large proportion of recent funding has been directed at building SA's newest of these – Tonsley, the South Australian Health and Medical Research Institute (SAHMRI) and Lot Fourteen.

The first half of this chapter examines SA Government policy (2.1). In the second half, this chapter discusses how Australian Government policy (section 2.2) and higher education policy (section 2.3) contribute to R&D in this state.

*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.<br><br>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:<br>• $780,000 to continue the Australian Centre for Plant Functional Genomics;<br>• $240,000 over two years through the Premier's Science and Industry Fund for innovation;<br>• and the Advanced Manufacturing Strategy. |

Key: Research institution (blue) · Innovation and science precinct (orange) · Other measure (white)

*Figure 2.1: (continued): Timeline of key R&D policy changes – 1980 to 2020*

| Australian Government | | South Australian Government |
|---|---|---|
| 2015: *National Innovation and Science Agenda* (NISA) announced providing funding of $1.1 billion nationally over four years to support 24 measures. | **2010-2015** | 2014: BioSA launched Tech Hub, its second business incubator. |
| | | 2014: The *Investing in Science Action Plan* becomes 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:<br>• $44 million for SAHMRI 2, and<br>• $6 million to establish the Australian Institute for Machine Learning. |
| | | 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:<br>• Approximately $1.3 million over four years to establish a new Australian Space Innovation Precinct; and<br>• $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 Start-Up 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 for NCRIS Investment in SA. |
| | | 2020: Chief Scientist's *Excite Strategic Plan 2020-2030* (to be announced). |

Key: Research institution; Innovation and science precinct; Other measure

*Source: South Australian Productivity Commission research of documents and sources*

## 2.1 South Australian Government R&D policy

### 2.1.1 History of R&D as an economic development policy

The South Australian Government has a long history of supporting R&D activities in the state, typically envisaging R&D as means to support broader economic objectives, including jobs creation, and industry support and transition. The focus has changed and evolved over time. This section outlines the main R&D policies of the SA Government through the past two decades.

***Economic Development Board and the Premier's Science and Research Council***

In 2002, the SA Government appointed an Economic Development Board (EDB) and set it two major initial tasks. The first of these, delivered in November of the same year, was the preparation of the 'State of the State' report — a comprehensive examination of South Australia's economic performance relative to other Australian states and territories. The second was to deliver a 'Framework for Economic Development' which outlined the key actions that business, the community and government should take to revitalise the South Australian economy and place the state on a higher growth path. The strategy noted the role of R&D in the economy:

> *Science, research and technology – and the innovations they give rise to – are the key drivers of economic growth. Together, they play a central role in creating sustainable, high quality and well-paid jobs in all sectors of the economy and in delivering improved living standards...*[10]

In recognising the state's extant strengths, the EDB noted the need to increase the level of investment in R&D capability and for that investment to be targeted to the areas with greatest potential for returns. The EDB also noted the need to increase the rate of private sector investment in R&D and proposed that the government investigate ways to achieve this. The EDB supported the strategic objectives of the Premier's Science and Research Council, including to:

- develop a plan for setting strategic priorities for R&D in SA;
- strengthen South Australia's R&D capability and infrastructure to ensure that they underpin future economic growth in the state;
- encourage greater levels of business investment in R&D;
- increase the rate of new business start-ups in South Australia through the commercialisation of research; and
- increase the uptake and diffusion of new product and process technologies into South Australian-based firms.

The SA Government also established the Premier's Science and Research Council in June 2002 to advise it on strategies for boosting local science and research capabilities and improving levels of innovation. A key deliverable of the Council, as set out in its terms of reference, was a 10-year strategy for science, research and development and commercialisation of intellectual property.

[10] Economic Development Board, *A Framework for Economic Development in South Australia* (November 2003), 14.

The Council recommended several key programs targeted at critical factors for a competitive R&D base in South Australia. Initiatives taken up by the government included:

- investing in improved high-performance computing capabilities (through the Hydra Computer – a $1.7m 'supercomputer');
- establishing a Premier's Science and Research Fund of $1 million per annum over four years; and
- establishing the South Australian Broadband Research and Education Network (SABRENet), to improve high speed broadband communications between the state's key research institutions.

***South Australia's Strategic Plan (SASP) and 10-Year Vision for Science, Technology and Innovation (STI$^{10}$)***

In 2004, the state government released 'South Australia's Strategic Plan' (SASP). The plan was presented as a whole-of-state plan. In time, all government plans would be aligned to the SASP and all government agencies would base their plans, budgets and programs on the SASP key directions, strategies and targets. Over its lifespan, the SASP was regularly reviewed, performance was audited and targets re-set, or new targets established. The first plan in 2004 set three specific targets for R&D activity in the state. They were to:

- increase patent applications to exceed the state's population share in all applications within five years;
- exceed the national average of business expenditure on research and development (as a percentage of Gross State Product) and to approach the OECD average within 10 years; and
- have based in South Australia either the headquarters or a major node of at least 40 per cent of all existing CRCs, major national research facilities and centres of excellence within five years.

A fourth aim was to improve the connections between educational institutions and industry to enhance creativity and innovation[11].

These targets would be modified, and new targets established in the 2007 and 2011 iterations of the SASP. Accompanying the SASP was the '10-Year Vision for Science, Technology and Innovation in South Australia – STI$^{10}$', also released in 2004. STI$^{10}$ originally included ten targets that were to be achieved ten years after their introduction in 2004 (box 2.1).

In early 2014, the government released 'Investing in Science' which was a response to the Premier's Research and Industry Council report 'Investing in Prosperity: The role of science, research and innovation'. The 'Investing In Science' strategy was based on seven pillars. Each pillar was underpinned by specific actions or initiatives. In mid-2014 the government also released a suite of 10 Economic Priorities, and R&D and innovation were key themes in several priority areas.

Table 2.1 sets out the elements of the 'Investing in Science' strategy.

[11] SA Government, *South Australia's Strategic Plan: Creating opportunity* (March 2004), 7.

*Table 2.1: SA Government 'Investing in Science' initiative key pillars and actions*

| Initiative | Description |
|---|---|
| **1. Investing in people, our current and future research leaders** | The immediate actions undertaken by the state government were to:<br>• increase the number of South Australian Research Fellowships offered to three per year, each worth up to $1 million over four years, and designed to attract global research leaders to South Australia;<br>• increase the number of Catalyst early-career researcher grants to up to 15 per year to provide the next generation of research leaders with industry focussed research experience; and<br>• introduce new grants to provide up to five collaborative projects for mid-career researchers to work with industry partners on research and collaborative projects, including with international partners. |
| **2. Investing in STEM skills to drive innovation and growth** | The objective was to position South Australia as leading the nation on STEM education at the school, vocational and higher education levels. The strategies and actions were based around communication and promotion of STEM activities to the community, students and industry, with a view to increasing STEM skills acquisition in the population. |
| **3. Investing in research to build on our strengths** | Immediate actions for implementation included several funding decisions including:<br>• establish the High Value Food Manufacturing Hub, to support the translation of applied research to value add to primary produce and create greater export opportunities for local manufacturers;<br>• create a Mining and Petroleum Services Centre of Excellence;<br>• provide continued support for Cooperative Research Centres of strategic importance to South Australia; and<br>• fast-track exploration and research in the Gawler Craton region of South Australia, in partnership with mining companies. |
| **4. Industry collaboration, entrepreneurship and commercialisation** | The State Government committed to:<br>• provide facilitation support to encourage the establishment of 'early stage' risk capital providers and venture capitalists in South Australia;<br>• provide $750,000 over three years to expand the Flinders University's Medical Device Partnering Program, which supported the development of hi-tech medical devices through collaboration between researchers, industry, consumers and government;<br>• invest $3 million over three years in the Innovation Voucher Program, which offered up to $50,000 in funding for businesses to work with researchers to find innovative solutions through technical research, design development and prototyping;<br>• work with the universities to develop a web-based platform to better connect research activity with industry, support innovation and facilitate collaboration with industry; and<br>• provide $3 million over three years for the Small Business Innovation Research pilot to support innovation in small and medium-sized enterprises |
| **5. Building strategic international partnerships** | Government actions included:<br>• establishing a coordinating committee to facilitate, support and provide advice on international research and industry opportunities in South Australia;<br>• expanding the Premier's Research and Industry Fund - International Research Grant Program to support new global research linkages, particularly in Asia, as well as those regions with world-leading capability in areas of strategic importance to the state;<br>• creating opportunities for international STEM students who have graduated from local universities to stay and work in South Australia; and<br>• in partnership with South Australia's universities, research institutes and Invest in South Australia, prepare a prospectus of South Australia's capabilities and expertise to promote and attract new investment into the State. |
| **6. Increasing wellbeing through publicly funded research** | Actions included:<br>• supporting investment in health and medical research in the state and strengthening South Australia's reputation and international standing in health |

| Initiative | Description |
|---|---|
| | and medical research through the establishment of the South Australian Health and Medical Research Institute;<br>• helping facilitate funding for commercialisation of technologies in health and biomedical sciences;<br>• investing $200,000 to help establish the South Australian Renewable Energy Institute in 2014 – a partnership between the State Government, the University of South Australia and Flinders University, which will focus on challenges associated with intermittent renewable energy resources such as wind, solar and wave power; and<br>• supporting implementation of South Australia's Climate Change Adaptation Framework by government, business and regional communities focusing on applying outcomes of research. |
| **7. Investing in strategic infrastructure** | Key actions/initiatives included:<br>• establishing and maintaining a proactive process to prioritise across government investment in major and shared use facilities, on a 3 to 5-year planning horizon;<br>• providing $1.4 million over five years to support the development of two entrepreneur and innovation hubs in Adelaide for young entrepreneurs;<br>• providing information on major and shared-use equipment and facilities currently available in South Australia;<br>• partnering with industry, universities and research institutes to enhance the awareness of technical and consulting services available in the state and<br>• advocating for, and assisting with, the attraction of major research infrastructure, where linked with state government strategic priorities. |

*Source: Investing in Science, 2014*

### *Reviewing the strategies*

STI[10] originally included ten targets that were to be achieved ten years after their introduction in 2004 (Box 2.1). The SA Government issued a progress report on the STI[10] Vision for the period 2004 to 2009. It noted capital investments such as: the Mawson Research Institute, the Wine Innovation Cluster, the operation of the Premier's Science and Research Fund, Marine Innovation SA, the Australian Centre for Plant Functional Genomics, the Australian Minerals Science Research Institute, the Mawson Institute of Advanced Manufacturing, the extension of SABRENet and funding committed to NCRIS projects in South Australia.

The progress report also noted the state's share of Commonwealth research funding, through the Australian Research Council, the National Health and Medical Research Council and rural R&D corporations, had increased to above population share, although still below the Vision target. The percentage of CRCs with a significant presence in the state had increased, as had venture capital investment in South Australia.

*Box 2.1 STI[10] targets*

1. Within 10 years, SA to secure 25 per cent above the per capita share of Commonwealth's R&D resources and SA to host the headquarters or major node of at least 40 per cent of all CRCs, Major National Research Facilities and Centres of Excellence.
2. Within 10 years, Business Expenditure on R&D (BERD) as a percentage of GSP to meet or exceed the national average and approach the OECD average, and SA to secure Commonwealth R&D grant/loan resources and other incentives 25 per cent abuse per capital share.
3. Within 10 years, triple the economic contribution of all precincts compared to a baseline audit set in June 2005.
4. Within 10 years, annualised growth of 15 per cent per year in the number, nature and value of STI-related contract and consultancy transactions between public and private sectors.
5. Within 10 years, annualised growth of 15 per cent per year in the number, nature and value of STI-related licencing, royalty, company formation and progression.

6. Within 5 years, venture capital investment in SA as a percentage of GSP/GDP to meet and exceed national levels.
7. Within 10 years, at least 10 SA firms ranked in top national 50 on 'Score-board' ratings. And within 5 years, number of IP applications lodged by SA residents to exceed SA's population share of all Australian applications.
8. Within 10 years, number and age of qualified science and maths teachers, and of science and engineering intake and graduates to exceed national benchmarks.
9. Within 10 years, through a tri-annual survey of community awareness, achieve immediate recognition of 80 per cent of the community and all demographics of key STI and innovation events/ issues (Target 9)
10. Within 10 years, SA Government support for R&D agencies to at least equal CPI each year and SA Government support for STI infrastructure and capability building to reach, on a per capita basis, at least the levels of investment made by eastern seaboard states.

The Commission's review of SA Government SASP documents indicates that by 2012, two targets had been achieved (see table 2.2). These were to:

- have based in SA either the headquarters or a major node of at least 40 per cent of all existing CRCs, Major National Research Facilities and Centres of Excellence within 5 years; and
- exceed average public investment in R&D as a proportion of GSP compared to other states.

Targets on increasing patent applications and business expenditure on R&D were not achieved at the 2007 progress update and were later replaced with new or modified targets. Targets on increasing innovation, set in 2004 and 2007, were discontinued because a meaningful measure for innovation could not be identified. Overall, the Commission has observed that SASP targets tended to shift over time, making it difficult to assess progress. Most targets were not met.

The SA Government's final report on the '10 Economic Priorities' released in 2017 recorded several achievements, such as the establishment of the Tonsley Innovation Precinct, and the implementation of the South Australian Rapid Commercialisation Initiative in 2016. Some goals, such as targeted increases in Business Expenditure on Research and Development (BERD), and in STEM students commencing undergraduate and postgraduate studies were not achieved.

*Table 2.2: 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**<br>**Achievability: Within Reach** | **Target modified** — previous target it did not measure the cumulative quantum of research dollars entering SA.<br>**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**<br>**Achievability: On Track** | **Target modified —** Timeframes were extended to be more realistic, but still ambitious.<br>**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**<br>**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**<br>**Achievability: Unclear** | **Target modified —** to better reflect the full range of federal R&D funding:<br>**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**<br>**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**<br>**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**<br>**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.*

### 2.1.2 Current SA Government policy

The SA Government's current economic policy is embodied in the *Growth State* initiative. Launched in 2019; *Growth State* supports the government's objectives to grow the state economy to 3 per cent per annum. It focuses on 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.

The SA Chief Scientist, whose role is to provide independent advice to the Premier, the Minister for Innovation and Skills and Cabinet, on matters of science, technology and innovation, is developing a strategy to contribute to *Growth State*, referred to as the *EXCITE Strategic Plan (2020-2030)*. In material provided to this inquiry, the Chief Scientist and the Department for Innovation and Skills describe EXCITE as a plan for research and innovation to ensure 'a high functioning research and innovation value chain'. No specific policy initiatives under the EXCITE strategy have been announced at the time this draft report was finalised. However, the SA Chief Scientist has advised that EXCITE will focus on:

- excellence of research and innovation outputs;
- collaboration between the world's best researchers and businesses, and between business and research to drive knowledge transfer;
- innovation and translation, including through commercialisation; and
- an enabled future workforce with skill in STEMM and technology-based industries[12].

The Department for Innovation and Skills (DIS) plays a leading role in R&D policy in the state. It has broad responsibility for supporting science, strategic initiatives and facilitates the state's engagement in Australian Government R&D programs (including NCRIS, the partnership between CSIRO and SRA, Centres of Excellence and Cooperative Research Centres)[13]. It also administers South Australia's Research, Commercialisation and Startup Fund. 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 current economic and industry policy. The framework delivers financial assistance to private sector entities through three designated funds, which are the:

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

[12] SA Chief Scientist, South Australia: *The State of Science – the EXCITE Strategic Plan*, p.3
[13] Department for Innovation and Skills, 2018-19 Annual Report, p.10

As HMR and R&D for primary industries account for 86 per cent of the state's total R&D expenditure (discussed in detail in Chapter 3), two other agencies are significant:

- 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).

A range of other agencies are also 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). Although policy development for Lot Fourteen is led by the Department of the Premier and Cabinet; the Department of Treasury and Finance, the Department for Trade and Investment, Defence SA, Renewal SA, the Chief Scientist and Chief Entrepreneur are all involved in various Lot Fourteen initiatives.

***Science and innovation precincts***

Science and innovation precincts continue to be a prominent feature of SA Government policy for industry support and innovation (Table 2.3). 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 terms of reference clearly state that the inquiry would examine trends in R&D and the factors which influence the extent to which R&D translates into economic growth in SA. The science and innovation precincts relate to factors that influence the extent to which R&D is translated to economic growth including the capacity of business located in the precincts to engage with relevant leading researchers and research groups within the associated universities and research institutes.

The report considers three groups: precincts operated by the state (Table 2.3); precincts where the State has a presence; and the institutions that the state supports.

The state operates three major science and innovation precincts – Mawson Lakes Technology Park, Tonsley Innovation District, and Lot Fourteen (discussed in detail in Chapter 5). Renewal SA has continuing responsibility for the management of the Tonsley precinct.

The state has a 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, the Goyder Institute, the Geological Survey of South Australia and SAHMRI.

*Table 2.3: SA science and innovation precincts*

| Precinct | Description |
|---|---|
| **Mawson Lakes Technology Park** | The SA Government has made substantial commitments to develop the internationally competitive technology precinct Technology Park Adelaide, since its inception in 1982. It is now home to over 100 high-technology companies in the defence and aerospace, health, training, engineering, advanced electronics and information communication technology sectors. Renewal SA leases a range of accommodation for high-technology businesses at the site (currently 69 tenants).<br><br>The *Salisbury City Plan 2020* lists the establishment of the Mawson Innovation Precinct (MIP) as a current strategic initiative. |
| **Tonsley Innovation District** | The former Mitsubishi site at Tonsley Park was transformed into a precinct for: cleantech and sustainable technologies and environmental industries; advanced manufacturing; and research and development. The Tonsley Innovation District is now an integrated, mixed use, employment precinct with education institutions and student accommodation.<br><br>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.<br><br>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 start-ups. |
| **Lot Fourteen** | Lot Fourteen is an innovation incubator and business start-up and growth hub located at the former Royal Adelaide Hospital site on North Terrace. It is backed by the SA and Australian governments and is a key focus of the $551 million Adelaide City Deal to provide a springboard for innovation, and bring together the state's leading abilities in space, defence, hi-tech and creative industries.<br><br>The precinct is in the formative stages of establishment. Its activities are intended to align with strategic sectors relevant to the state government priority sectors of defence and space, cyber security, food and wine, medical technologies, robotics, media and film. Tenants will be chosen with a bias towards technology development including capabilities in AI, machine learning, data analytics or cyber security, as enablers for growth in other sectors. |

*Source: South Australian Productivity Commission research of documents and sources*

In 2008, the SA Government launched the Thebarton Bioscience Precinct as the home for Australia's first bioscience incubator. It launched its second business incubator, the Tech Hub, in 2014. The state's bioscience agenda has been subject to significant reforms in recent years. Bio Innovation SA (the state government body responsible for promoting bioscience industry growth) became TechInSA in 2016, and under new regulations, its remit was expanded to high-tech industries[14]. However, TechInSA is being wound down, with services for entrepreneurs and start-ups moved to the Office of the Chief Entrepreneur[15]. Tenancies at the Thebarton Bioscience Precinct will be honoured until their contracted end date.

***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[16]. 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.

A 2016 review of SARDI found that the withdrawal of SA Government funding over recent years has caused SARDI to become highly reliant on external funding sources. SARDI receives an annual state allocation, as well as PIRSA funding, to deliver specified functions on a cost-recovery basis through service level agreements. Over the course of one decade, SARDI's state allocations declined to 33 per cent less than its ten-year average. Nevertheless, SARDI has maintained its funding levels through a 12 per cent increase in cost-recovery funded activities and an 18 per cent increase in external R&D funding (principally through the Australian Government's Rural RDC program).

PIRSA has advised the Commission that SARDI's external revenue now accounts for 65 per cent of total funding, and its reliance on cost -recovery activities constrains its ability to compete effectively in primary industries R&D. It has also expressed concern that changes that may result from the Australian Government's current review of rural RDCs (and their administered R&D funding) could compromise SARDI's ability to maintain its research funding and capabilities.

***Other key institutions and partnerships***

Other (much smaller scale) SA Government entities which provide public-facing research services are:

- Australian Water Quality Centre, 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 of Energy and Mining (DEM).

The SA Government has also maintained long-term institutional partnerships with the Goyder Institute on water research, and with the Waite Institute on agricultural research through SARDI's presence at the Plant Research Centre. Table 2.4 provides information on SA Government R&D entities, while Table 2.5 provides information on major institutional partnerships.

[14] *Public Corporations Act (TechInSA) Regulations 2016*
[15] 2018-19 Budget Measures Statement, p. 100; Premier of South Australia, 'SA's New Entrepreneurship Model', Media Release (2018).
[16] Department for Primary Industries and Regions SA, *SARDI Strategic Plan 2018-2023* (2019).

*Table 2.4: South Australian Government R&D entities*

| Organisation | Research focus | South Australian activity |
| --- | --- | --- |
| **South Australian Research and Development Institute (SARDI)** | • Production and profitability of primary industries, food and wine<br>• Sustainable management of natural resources that underpin primary industries production<br>• Protecting and enhancing market access for South Australian businesses and products<br>• Food innovation | SARDI has a presence at three metropolitan research centres: the Waite Research Precinct and the Plant Research Centre (both co-located with the University of Adelaide), and the SA Aquatic Sciences Centre (located at West Beach). It also has 10 regional research centres.<br>SARDI identifies and commercialises its intellectual property, through knowledge transfer, licensing or fee for service, to increase industry development. Revenue from intellectual property commercialisation is reinvested in relevant research and development. |
| **Australian Water Quality Centre (AWQC)** | Projects contribute directly to water and wastewater services to provide continuous, high quality supply, protect the health of the public and minimise environmental impacts. | The Centre has laboratory facilities in SA Water House covering microbiology, chemistry services, research services and quality control. |
| **Geological Survey** | Collects, manages and delivers information and knowledge of SA's geology, particularly for the mineral resources sector<br>Conducts research and development of digital mapping techniques for SA into databases, enabling rapid delivery through the SA Resources Information Gateway (SARIG) | Contributes to South Australian-focused collaborative projects with other state and federal government agencies, universities and research bodies.<br>Maintains a drill core library at the Tonsley facility, including collections and samples for use by researchers. |

*Source: South Australian Productivity Commission research of documents and sources*

*Table 2.5: South Australian Government R&D institutional partnerships*

| Organisation | Research focus | Links with other institutions |
|---|---|---|
| **SA Health and Medical Research Institute (SAHMRI)** | SAHMRI's current research themes include precision medicine, lifelong health, Aboriginal health equity, and women and kids. | SAHMRI was incorporated with a total of six members, all of whom continue to be members of the company: the Minister for Health; the Minister for Science and the Information Economy; the Treasurer; the University of Adelaide; Flinders University; and the University of South Australia. SAHMRI is a collaborating partner of Adelaide BioMed City. |
| **Goyder Institute** | An independent expert science advisor providing quality, evidence-based knowledge on water management issues important for policy making in South Australia | Operates as a partnership between DEW, CSIRO, Flinders University, the University of Adelaide, the University of South Australia and The International Centre of Excellence in Water Resources Management. SA Government funding is provided through DEW. |
| **Waite Research Precinct** | Focuses on agricultural research, education and commercialisation. The Waite Institute has the largest concentration of expertise in the southern hemisphere in the areas of plant biotechnology, cereal breeding, sustainable agriculture, wine, food, horticulture and land management. | SARDI is an institutional partner and is located at the Plant Research Centre at the Waite Institute. The Waite Institute also partners with CSIRO, the Australian Wine Research Institute (AWRI), and companies including Australian Genome Research Facility and Plant & Food Research Australia. |

*Source: South Australian Productivity Commission research of documents and sources*

Although HMR is outside the scope of this inquiry, it is worth noting that the SA Government's main partnership on R&D in the health and medical fields was established and recently expanded through the South Australian Health and Medical Research Institute (SAHMRI) — the state's flagship independent HMR institute. The SA Government funded SAHMRI's new infrastructure projects, and the Commission understands that DHW provides approximately $5-6 million annually to SAHMRI as an operating grant. SAHMRI is also a partner in the new Adelaide Biomed City precinct, which focuses on research, education, clinical care and population health.

### *Expenditure on R&D measures 2015-16 to 2019-20*

Figure 2.2 illustrates the flow of SA Government expenditure from new Budget measures committed in the five years from 2015-16 to 2019-20, with expenditure totals grouped by purpose on the right-hand side.

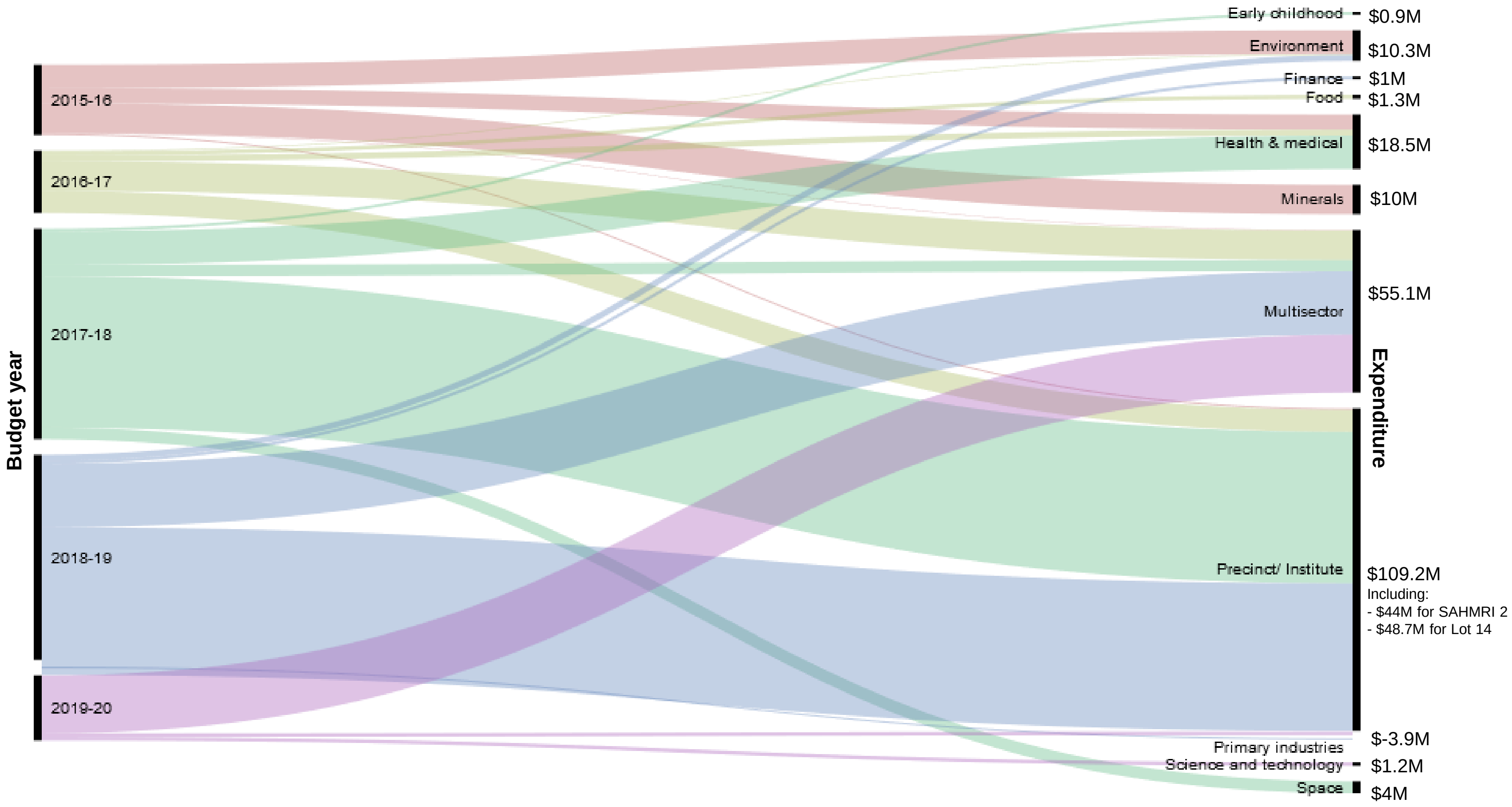
The SA Government committed an estimated $207.4 million[17] in new R&D measures since 2015-16 for R&D-related projects across diverse fields, notably:

- More than half of new funding ($109.2 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 $55.1 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 benefitted the most from new R&D spending ($18.5 million), with a substantial amount allocated as SAHMRI operational grant funding ($5.1 million allocated in 2015-16)[18].
- Funding for primary industries R&D declined 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 was partially offset by new investment for a Pulse Cooperative Research Centre, allocated to PIRSA.
- The remaining funding ($28.6 million) was spread thinly across R&D initiatives in areas of early childhood, environment, finance, food, minerals, science and technology, and space

[17] Commission estimate based on an analysis of Budget Measures Papers and Mid-year Budget Reviews from 2015-16 to 2019-20. 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.

[18] 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 the 2015-16 to 2019-20, 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

The Commission has found little evidence of systematic evaluation of R&D-related policies and programs, with government agencies providing few evaluations in response to the Commission's information request for this inquiry. The most significant of these evaluations are outlined below. Overall, the Commission notes that despite decades of state government spending on R&D policies and programs, there is very little evidence to demonstrate impact and value for money.

***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. To address this, 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*. As discussed earlier, the review also highlighted tensions in SARDI's funding model that could compromise its ability to be responsive to industry regarding its research priorities.

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

A few, very broad evaluations have been conducted on SA's innovation and business support policies, which are 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 Commission has been provided the final report (completed in 2016), which among other issues, identified problems around inefficient administration, a lack of a co-ordinated approach across government, and insufficient data collection on performance[19].
- In 2017, the then Department of State Development commissioned consultant, Econsearch, to assess the outcomes of 20 industry and economic development programs delivered by its Innovation, Science and Small Business Division. The evaluation appeared to be wholly retrospective since it 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 (it estimated the direct and estimated flow-on impact of government expenditure to GSP and to employment)[20].

***Evaluations on the performance of precincts***

Monitoring of SA's science and technology precincts appears ad hoc. The Commission has found evidence that Tonsley has been evaluated several times since establishment. Previously, Bio Innovation SA was subject to regular evaluations between 2001 and 2011, which tracked the efficacy of the SA Government's bioscience activities against the growth of the bioscience industry, and outcomes against the government's strategic plans. These evaluations suggested that Bio Innovation SA had a positive impact on R&D activity in the

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

sector. It initially sought to create 50 new bioscience companies & 2,500 new bioscience jobs by 2010[21]. Progress evaluation documents reviewed by the Commission suggest that progress was made toward the targets but were not fully realised. By 2009, 900 new jobs were reported to have been created, and progress toward the company target was "better than expected"[22]. Later, a 2011 SA Government report stated that the 2,500 jobs target for bioscience was expected to be achieved by the end of 2015[23].

**Information request 2.1**

The Commission seeks further information on R&D policy and programs in South Australia:

- What else can we learn from the state's previous R&D initiatives and economic strategies?
- Was the use of economy-wide targets under the SASP and STI[10] an effective way of compelling change and measuring performance?
- Are there any other initiatives or institutions that the Commission should consider in understanding the R&D system and performance in SA? How should these be improved?

## 2.2 Links to Australian Government policy

The Australian Government is a significant funder of R&D activity nationally. Table 2.6 shows the split of Australian Government investment in R&D across policy areas. 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).

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 of 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 discussed briefly below, and in detail in Appendix 2.

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[21] SA Government, *Submission by the South Australian Government to the Productivity Commission Inquiry into Science and Innovation (2004).*
[22] Access Economics, *Evaluation of Bio Innovation SA* (2009).
[23] SA Government, *Building a BioEconomy in South Australia 2011-2015 — the Next Five Years: Our plan for your future* (2011).

Table 2.6: Australian Government investment in R&D by program, by sector, *2019-20*

| Program | $m |
|---|---|
| **Investment in intramural R&D** | |
| **Australian Government research activities** | |
| CSIRO | 839 |
| Defence Science & Technology (DST) Group | 468 |
| Australian Government (Other R&D) | 790 |
| ***Sub-total*** | ***2,097*** |
| **Investment in extramural R&D** | |
| **Business Enterprise sector** | |
| Industry R&D tax measures | 2,012 |
| Business (Other R&D) | 51 |
| ***Sub-total*** | ***2,063*** |
| **Higher education sector** | |
| Australian Research Council (ARC) | 791 |
| NHMRC (University) | 647 |
| Research block grants | 1,938 |
| Higher education (Other R&D) | 237 |
| ***Sub-total*** | ***3,614*** |
| **Multisector** | |
| NHMRC (Government, MRI, Hospital, Other) | 221 |
| Other Health | 519 |
| Cooperative Research Centres (CRCs) | 184 |
| Rural R&D Corporations | 342 |
| Other rural R&D | 31 |
| Energy and the Environment | 286 |
| Other R&D | 255(1) |
| ***Sub-total*** | ***1,839*** |
| **Private Non-profit sector** | 10 |
| **Rest of the World** | 12 |
| **Total R&D investment** | ***9,636*** |

*Source: Department of Industry, Innovation and Science, 2019-20 Science, Research and Innovation Budget Tables (errors due to rounding)*
*Note to table: (1) The Medical Research Future Fund (MRFF) is included in 'Other Health' as a multi-sector R&D program.*

## 2.2.1 The R&D Tax Incentive

This is the Australian Government's preferred policy instrument to increase business investment in R&D by providing a tax concession. A 2016 review of the R&D Tax Incentive found that the program was falling short of its stated objectives and that it was not achieving the intended economic impacts of additionality and spillovers[24]. In response, the Australian Government announced it would amend the R&D Tax Incentive to better target it 'towards additional R&D activities, and improve the fiscal sustainability, integrity and administration of

[24] Bill Ferris, Alan Finkle & John Fraser, *Review of the R&D Tax Incentive* (Commonwealth of Australia, 2016).

the program'[25]. Overall, the proposed changes will make the R&D Tax Incentive less valuable to many entities. Some participants to this inquiry have expressed concern about the impact for South Australian businesses. For example, PricewaterhouseCoopers (PwC) made the point that businesses in capital intensive industries, such as manufacturing, may be less likely to qualify for the research intensity-based R&D tax offset for large R&D entities. Other participants highlighted that, irrespective of the reforms, the complexity and lack of consistency in the application of the rules creates uncertainty in making R&D investment decisions, which is especially detrimental for small businesses. The Australian Small Business and Family Enterprise Ombudsman (ASBFEO) raised these same concerns in her 2019 review report on the R&D Tax Incentive[26] and in the ASBFEO's recent submission on the R&D tax incentive Bill.

### 2.2.2 R&D institutions

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 Industry 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 the Edinburgh facility in Adelaide, which is home to more than 1,200 highly skilled scientists, engineers, IT specialists and support staff undertaking military research in areas such as: surveillance systems, autonomous systems, electronic warfare, information systems, propulsion and energy, weapons effects, human science and operations analysis[27]. DST Groups' research priorities are articulated through the STaR Shots initiative[28]. It also has an active 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[29].

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[30]. Wine Australia is a statutory RDC with a significant presence in South Australia, as its head office is located in Adelaide. The Fisheries Research and

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[25] Parliament of the Commonwealth of Australia, *Treasury Laws Amendment (Research and Development Tax Incentive) Bill 2019: Explanatory Memorandum (2019)*, 51, <https://parlinfo.aph.gov.au/parlInfo/download/legislation/ems/r6473_ems_a861d314-41c0-489b-b96e-875db0d25b75/upload_pdf/723652.pdf;fileType=application%2Fpdf>

[26] Australian Small Business and Family Enterprise Ombudsman, *Review of the R&D Tax Incentive* (Commonwealth of Australia, 2019).

[27] Defence SA, Defence Science and Technology, (Web Page, undated) <https://www.defencesa.com/domains/research/defence-science-and-technology>

[28] Department of Defence, Strategy: Science, Technology and Research (STaR) Shots, (2020) < https://www.dst.defence.gov.au/strategy/defence-science-and-technology-strategy-2030/science-technology-and-research-star-shots>

[29] Department of Defence, Defence Research Collaboration Security Framework, (2020) <https://www.dst.defence.gov.au/partner-with-us/defence-research-collaboration-security-framework>

[30] '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>

Development Corporation and the Grains Research and Development Corporation are also statutory RDCs with offices in South Australia.

### 2.2.3 Competitive grant funding

The Australian Government provides direct assistance for R&D activities through a range of competitive grant programs. Much of this funding is directed towards the higher education sector (discussed in section 2.3) but it also benefits private and industry-led R&D entities. The Australian Government's major R&D grant schemes are:

- The National Competitive Grants Program: The Australian Research Council (ARC) administers the National Competitive Grants Program (NCGP), which aims to support high-quality fundamental and applied research and training through national competition. In 2018-19, the ARC administered $714 million though the NCGP.

- Grants for health and medical research: Although the subject of a separate Commission inquiry, it is important to recognise the prominence of health and medical research (HMR) in government policy. R&D for HMR remains a top priority for the Australian Government. In 2018-19, it spent $1.2 billion directly targeting HMR initiatives[31], representing around 8 per cent of total R&D expenditure. Central to this policy is the National Health and Medical Research Council (NHMRC), which is Australia's peak body for supporting HMR. The Australian Government has also established the Medical Research Future Fund (MRFF) — a $20 billion long-term fund that supports HMR to improves lives, build the economy and contribute to health system sustainability. South Australia's share of MRFF funding stands at 3.1 per cent, totalling $18.5 million for ten grants[32].

- The Cooperative Research Centre Program: This targets competitiveness and productivity by helping industry to partner with the research sector to solve industry-identified issues. To be eligible for funding, a CRC must include at least one business and one research organisation. The Commonwealth currently provides funding for 15 CRCs across the country[33]. Links to South Australia include the Smart SAT CRC, the Innovative Manufacturing CRC and the Fight Food Waste CRC. The SA Government is leveraging on the Australian Government's CRC program through the Research, Commercialisation and Startup Fund, offering $2.4 million over three years to support CRCs headquartered or with a node located in SA[34].

- National Collaborative Research Infrastructure Strategy: This is a national network of world class research infrastructure projects that support high quality research. It works with the research sector to identify priorities for research infrastructure and supports 40,000 domestic and international researchers each year. There are currently 23 funded NCRIS projects nationally, with only one being headquartered in South Australia — the Australia Plant Phenomics Facility at the Waite Research Institute, University of Adelaide. However, South Australian universities and

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31 This is the total of funding spent through NHMRC, the Medical Research Future Fund, and 'other health'. The true value of expenditure on health and medical research will be higher because this does not include funding from general R&D grants or university block funding that is allocated for health and medical research.
32 MRFF, consolidated data as at Jan 31, 2020
33 Current Cooperative Research Centres, Business.gov.au (Website, July 2020) <www.business.gov.au/Grants-and-Programs/Cooperative-Research-Centres-CRC-Grants/Current-Cooperative-Research-Centres-CRCs>
34 David Pisoni, 'Funding to Support Industry-led Research in SA' (2020) <https://www.premier.sa.gov.au/news/media-releases/news/funding-to-support-industry-led-research-in-south-australia>

researchers also participate in multiple NCRIS project nodes led by interstate institutions.

## 2.3 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 players in the R&D sector in South Australia. Table 2.7 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 2.7 South Australian universities and their current areas of research*

| Organisation | Research focus | Locations |
|---|---|---|
| **University of Adelaide** | The principle foci are:<br>• photonics and advanced sensing<br>• mineral energy and resources<br>• machine learning<br>• agriculture, food and wine<br>• human reproduction and clinical health<br>• material characterisation and fabrication<br>• 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:<br>• an age-friendly world;<br>• transforming industries;<br>• cancer prevention and management;<br>• scarce resources;<br>• healthy futures; and<br>• 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.<br>Areas of research strength are grouped into a number of research institutes and centres.<br>Areas of research strength include:<br>• health and medical research;<br>• nanotechnology;<br>• industry 4.0 research, focussing on DST and defence industry collaborative research programs; | The Tonsley precinct houses:<br>• The Australian Industrial Transformation Institute, undertaking trans-disciplinary industry and workplace research in support of industrial and workplace transformation.<br>• The Institute of Nanoscale Science and Technology, a hub of nanotechnology research and education.<br>The precinct is also home to technology focussed health and medical research capability, including the Medical Devices Research Institute, the Medical Devices Partnering Program and the Flinders Digital Health Research Program. |

| | | |
|---|---|---|
| | • archaeology and history, with particular strength in maritime and indigenous archaeology;<br>• ecology with a focus on palaeontology;<br>• marine science research;<br>• water research;<br>• medical engineering research;<br>• security and resilience research; and<br>• creative arts research. | |

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

The Commonwealth 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.

## 2.4 Conclusion

R&D policy in SA reflects a complex policy and regulatory environment involving many different institutions, policies and programs, delivered at both the Commonwealth and state levels. The State is a comparatively small player compared to the Australian Government in R&D investment. Nevertheless, the SA Government over decades has sought to promote R&D as a means of improving the states' industry and economic performance. Public support is well established for R&D in agriculture, food and agribusiness, water and environment, defence, and HMR, while policy focus has more recently shifted toward science, engineering and tech-related industries. Science and technology precincts also continue to be an important feature in SA's R&D sector and have attracted substantial government funding over recent years, especially for the construction of new facilities.

Overall, the Commission has found little evidence that initiatives designed to use R&D as a lever for economic growth have had measurable impacts. This reflects both limited commitment to evaluation as a tool as well as the nature of the programs. A review of past SA Government R&D and innovation strategies, such as SASP and STI[10], suggests that the economic impacts of previous strategies have been modest at best. There appears to be limited systematic evaluation of R&D initiatives. Initiatives are continually being announced, but it is rare for agencies to look back at what has been achieved. Data constraints seem to be significant which in turn limits the quality of evaluations. A key factor seems to be that evaluation strategies and the necessary data capture for monitoring and evaluation are generally not established when initiatives are designed and implemented.

It is vital that initiatives are rigorously monitored and evaluated to understand their impact and inform future policy development. Greater transparency, accountability and simplicity in policy is needed to ensure that SA Government investment in R&D delivers maximum impact and value for money.

# 3. R&D funding and expenditure

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

Section 3.1 summarises how R&D is funded in South Australia, including who are the key funding bodies, what state and Australian government programs support R&D and trends in each type of funding. Section 3.2 identifies where R&D expenditure occurs, including the levels of R&D expenditure, what types of research is funded, what sectors of the economy conduct R&D and how South Australia compares to Australia as a whole. Finally, section 3.3 reviews the data available on the size of the R&D workforce in South Australia and where it is located.

Overall the Commission finds that in terms of expenditure, South Australia has a high level of R&D activity relative to other states in Australia but has a different composition of R&D across sectors than the national total. South Australia has high levels of higher education, Australian Government and state government expenditure as a per cent of Gross State Product, but lower levels of business expenditure than for Australia as a whole.

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

In seeking to build a picture of the R&D sector in South Australia, the Commission has been limited by the range and quality of the data available. The Australian Bureau of Statistics (ABS) presents 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[35] to define R&D and each sector definition is based on where 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 has 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 has 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, South Australian Government agencies have no requirement to regularly report their R&D expenditure. While agencies have been helpful in assisting the Commission to identify their expenditure, data was not available for all years for some agencies and it is likely that some R&D expenditure has been omitted.

[35] 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).

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.

As far as the Commission is aware, this is the first time this comprehensive picture has been done for South Australia.

## 3.1 How is R&D funded?

### 3.1.1 Australian Government

Approximately 85 per cent of Australian Government expenditure on R&D nationally is funded solely by the Australian Government. This includes 74.8 per cent funded through the budget of the agency conducting the R&D and a further 10.1 per cent funded by other Australian Government agencies (e.g. Australian Government departments purchasing R&D from CSIRO).

*Table 3.1: Australian Government expenditure on R&D, by source of funds, Australia, 2018-19*

| Source of funds | $'000 | Per cent |
|---|---|---|
| Own funds | 1,578,780 | 74.8 |
| Other Commonwealth government | 213,320 | 10.1 |
| Other state and local government | 59,875 | 2.8 |
| Private non-profit organisations | 5,848 | 0.3 |
| Business | 113,339 | 5.4 |
| Joint business/government | 44,223 | 2.1 |
| Universities | 7,232 | 0.3 |
| Donations and bequests | 0 | 0.0 |
| Other Australian | 3,312 | 0.2 |
| Overseas | 84,493 | 4.0 |
| **Total** | **2,110,422** | **100.0** |

*Source: ABS 8109.0*

The remaining 15 per cent of expenditure consists of funding from overseas (4 per cent), research funded solely by business (5.4 per cent), joint funding by businesses (2.1 per cent), and by other state and local governments (2.8 per cent). The proportions of each source of funding have remained relatively unchanged since 2004-05.

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

| Portfolio | $m | % of total |
|---|---|---|
| Industry, Innovation and Science | 3,662.44 | 38.0 |
| Education and Training | 3,117.58 | 32.4 |
| Health | 1,405.64 | 14.6 |
| Defence | 476.46 | 4.9 |
| Environment and Energy | 432.25 | 4.5 |
| Agriculture and Water Resources | 378.04 | 3.9 |
| Foreign Affairs and Trade | 101.46 | 1.1 |
| Social Services | 39.57 | 0.4 |
| Veterans' Affairs | 9.39 | 0.1 |
| Home Affairs | 5.11 | 0.1 |

| Portfolio | $m | % of total |
|---|---|---|
| Prime Minister and Cabinet | 4.82 | 0.1 |
| Treasury | 1.83 | 0.0 |
| Infrastructure, Regional Development and Cities | 1.17 | 0.0 |
| Jobs and Small Business | 0.05 | 0.0 |
| Communications and the Arts | 0.00 | 0.0 |
| Human Services | 0.00 | 0.0 |
| **Total** | **9,635.82** | **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, 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.

*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 & Technology Organisation (ANSTO) | 257.8 | 2.9 |
| Australian Renewable Energy Agency (ARENA) | 230.3 | 2.6 |
| National Institutes Program – ANU 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[36] ($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.

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

Rural Research and Development Corporations (RDCs) are one of the main funders of agricultural R&D in Australia, 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. RDC's are the largest funding source of SARDI, providing approximately $30 million annually.

The Australian Government is currently considering modernising the RDC framework.

### 3.1.2 State government

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.

*Table 3.4: State/territory government expenditure on R&D, by source of funds, all states, 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*

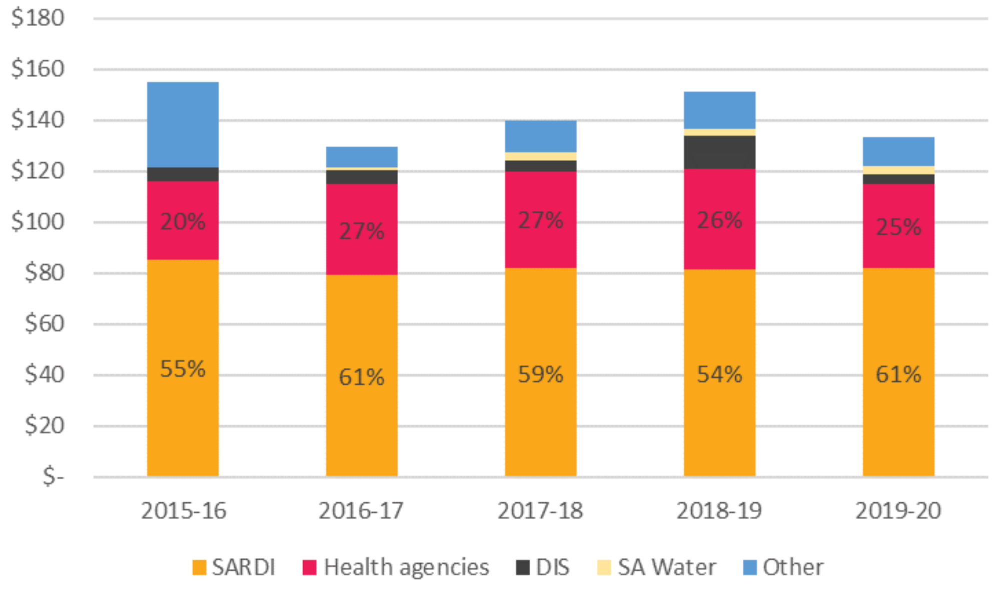
Across Australia, almost half (49.3 per cent) of state and territory government expenditure on R&D is financed solely by the agency conducting the R&D, with a further 10.4 per cent funded by either other agencies, or other state and local governments.

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).

In South Australia, SARDI represented over half of South Australian Government expenditure on R&D in 2018-19, as shown in Figure 3.1.

[36] Including NHMRC, ARC, MRFF

*Figure 3.1: South Australian Government identified expenditure on R&D, by agency, $m, 2015-16 to 2019-20*

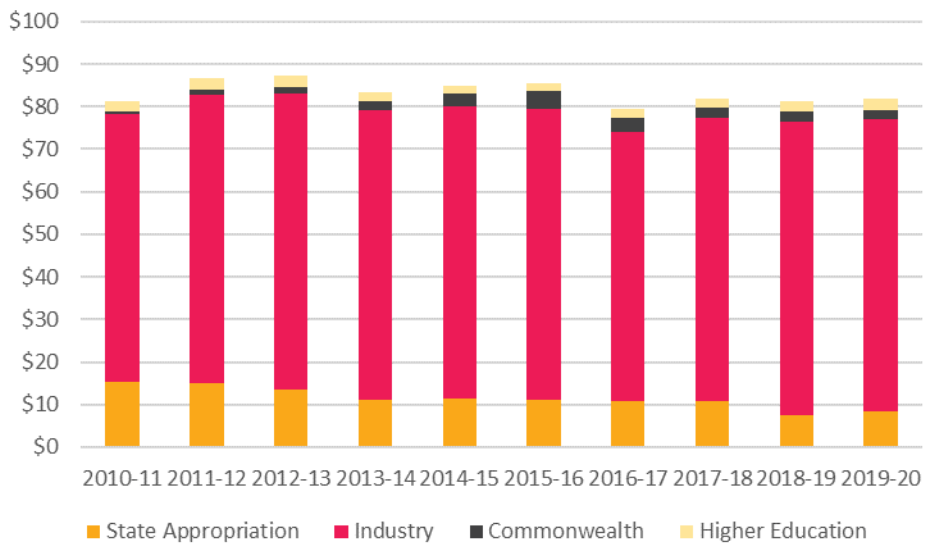



*Source: Agency data requests*[37]

While SARDI represents over $80 million in expenditure on R&D per year, SARDI raises significant funding from industry and other partners. A large portion of this co-investment is through RDCs (approximately $30 million annually). State government revenue represents approximately one sixth of this expenditure.[38] State government base funding for SARDI has decreased significantly from a peak of 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.

[37] 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.
[38] PIRSA submission, p.18

*Figure 3.2: SARDI R&D expenditure, by source of funds, $m*




*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 state budgets, Australian Government funding, businesses or other sources.

### 3.1.3 Higher education

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 3.5.

*Table 3.5: Higher education expenditure on R&D, by source of funds, by location, 2018*

| | South Australia | | Australia | | South Australia's share of national |
|---|---|---|---|---|---|
| Source of Funds | $ 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[39] 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.[40]

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.

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.

*Table 3.6: South Australia's share of national higher education expenditure on R&D by source of funding, 2006 and 2018*

| | **SA share of national (%)** | | **Compound annual growth rate (%)** | |
|---|---|---|---|---|
| **Source of Funding** | 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*

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.

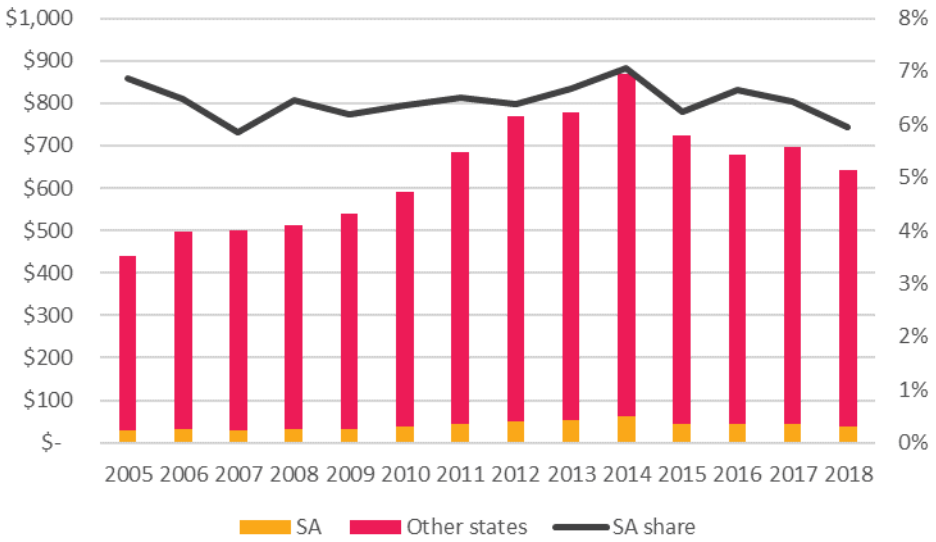
[39] Deloitte Access Economics, *Cost of Delivery of Higher Education*, (2016), Final Report, p. xxii
[40] A Norton, How reliant is Australian university research on international student profits? (2020), Blog post, < https://andrewnorton.net.au/2020/05/21/how-reliant-is-australian-university-research-on-international-student-profits/>

### *Australian Government support for higher education R&D*

National Competitive Grants Program

South Australia's major universities received an income of $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 3.3.

*Figure 3.3: 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 is examining 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 existing programs. South Australian universities' funding under the RSP, RTP, and their predecessors, have 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 deliver research infrastructure through the NCRIS[41]. This has attracted more than $1 billion in co-investment from state and territory governments, universities, research facilities and industry.

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.

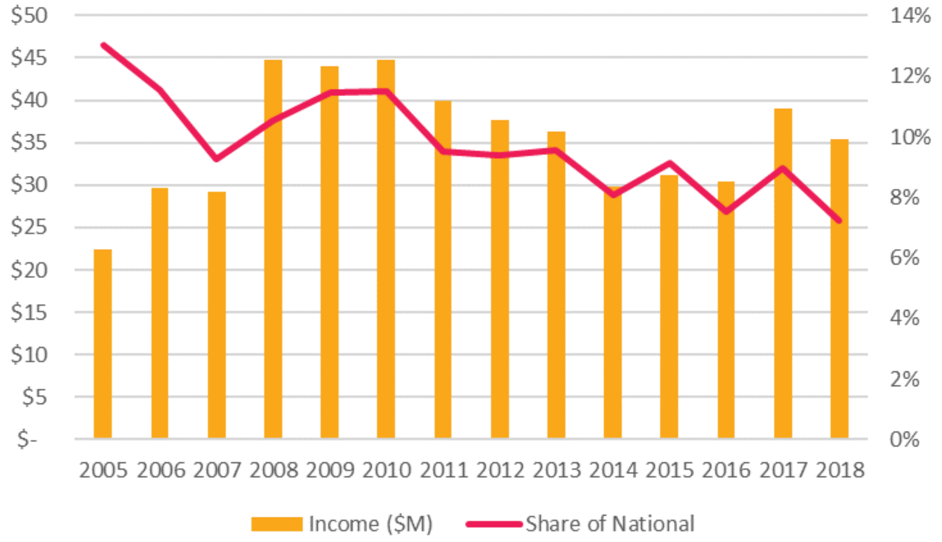
### *South Australian Government funding for higher education R&D*

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 Submission, 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 3.6. The Commission has not been able to estimate South Australian Government funding as this figure includes income from other state governments.

*Figure 3.6: South Australian Universities' R&D income from state governments, $ million, 2005-18*




*Source: Department of Education, Skills and Employment HERDC*

[41] 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 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.

### 3.1.4 Business

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 3.7.

*Table 3.7: Business expenditure on R&D, by employment size, Australia, 2016-17, $'000*

| Industry | Number of Employees | | | | Total expenditure on R&D |
|---|---|---|---|---|---|
| | 0-4 | 5-19 | 20-199 | 200+ | |
| Agriculture, Forestry and Fishing | 29,732 | 34,795 | 161,259 | 87,811 | 313,596 |
| Mining | 128,989 | 179,434 | 168,484 | 572,899 | 1,049,805 |
| Manufacturing | 132,170 | 378,726 | 1,039,336 | 3,049,232 | 4,599,464 |
| Electricity, Gas, Water and Waste Services | 16,177 | 82,104 | 19,493 | 235,245 | 353,020 |
| Construction | 30,745 | 56,367 | 96,837 | 165,215 | 349,164 |
| Wholesale Trade | 37,618 | 177,754 | 375,911 | 339,250 | 930,532 |
| Retail Trade | 28,763 | 59,017 | 94,079 | 60,345 | 242,204 |
| Accommodation and Food Services | 1,031 | 5,259 | 12,045 | 19,503 | 37,838 |
| Transport, Postal and Warehousing | 2,458 | 13,563 | 31,084 | 73,318 | 120,423 |
| Information Media and Telecommunications | 47,506 | 119,848 | 131,914 | 310,783 | 610,052 |
| Financial and Insurance Services | 24,817 | 116,926 | 288,419 | 2,416,829 | 2,846,990 |
| Rental, Hiring and Real Estate Services | 30,913 | 50,805 | 75,084 | 37,012 | 193,815 |
| Professional, Scientific and Technical Services | 753,470 | 1,330,956 | 1,801,250 | 1,227,447 | 5,113,123 |
| Administrative and Support Services | 8,825 | 27,634 | 51,188 | 79,154 | 166,800 |
| Public Administration and Safety | 3,056 | - | 13,533 | - | 21,889 |
| Education and Training | 8,004 | - | 21,713 | - | 50,604 |
| Health Care and Social Assistance | 33,078 | 24,252 | 48,177 | 35,317 | 140,823 |
| Arts and Recreation Services | 5,417 | 7,215 | 46,213 | 63,943 | 122,788 |
| Other Services | 26,782 | 46,469 | 61,128 | 40,274 | 174,653 |
| **All Industries** | **1,349,551** | **2,730,556** | **4,537,145** | **8,820,333** | **17,437,585** |
| **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[42], 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 their own R&D with only minor contributions from other funding sources.

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

*Table 3.8: Business expenditure on R&D, by source of funds, Australia, 2017-18*

| Source of funds | $'000 | Per cent |
|---|---|---|
| Own funds | 16,547,715 | 94.9 |
| Other business | 169,096 | 1.0 |
| Australian government | 360,752 | 2.1 |
| State and local government | 56,227 | 0.3 |
| Other Australian | 30,411 | 0.2 |
| Overseas | 273,384 | 1.6 |
| **Total expenditure on R&D** | **17,437,585** | **100.0** |

*Source: ABS 8104.0*

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.

### 3.1.5 Private non-profit

Table 3.9 presents expenditure on R&D by private non-profit organisations by the source of funds nationally.

*Table 3.9: Private non-profit expenditure on R&D, by source of funds, Australia, 2016-17*

| Source of funds | $'000 | Per cent |
|---|---|---|
| Own funds | 244,113 | 23.5 |
| Commonwealth government | 384,216 | 37.0 |
| State and local government | 109,295 | 10.5 |
| Other private non-profit organisations | 124,916 | 12.0 |
| Business | 58,525 | 5.6 |
| Joint business/government | - | - |
| Universities | 16,247 | 1.6 |
| Donations and bequests | 44,746 | 4.3 |
| Other Australian | - | - |
| Overseas | 50,983 | 4.9 |
| **Total** | **1,269,233** | **100.0** |

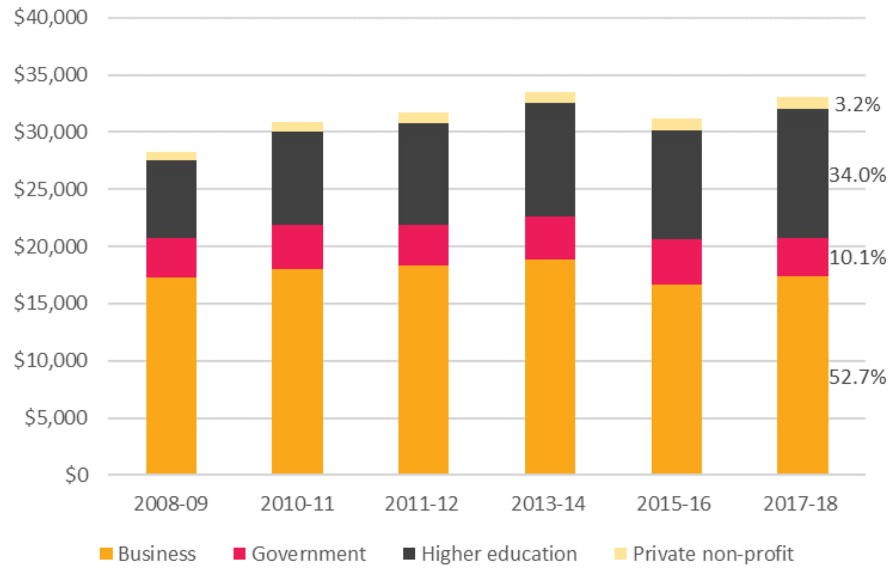
*Source: ABS 8109.0*

Across Australia, almost half of private non-profit expenditure on R&D is financed by either the Australian Government (37 per cent) or state and local governments (10.5 per cent).

## 3.2 Levels and patterns in R&D expenditure

Overall, a significant amount of resources is devoted to R&D in South Australia each year. Across Australia, 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 3.7: Gross expenditure on R&D by sector, Australia ($m)*




*Source: ABS 8104.0*

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.

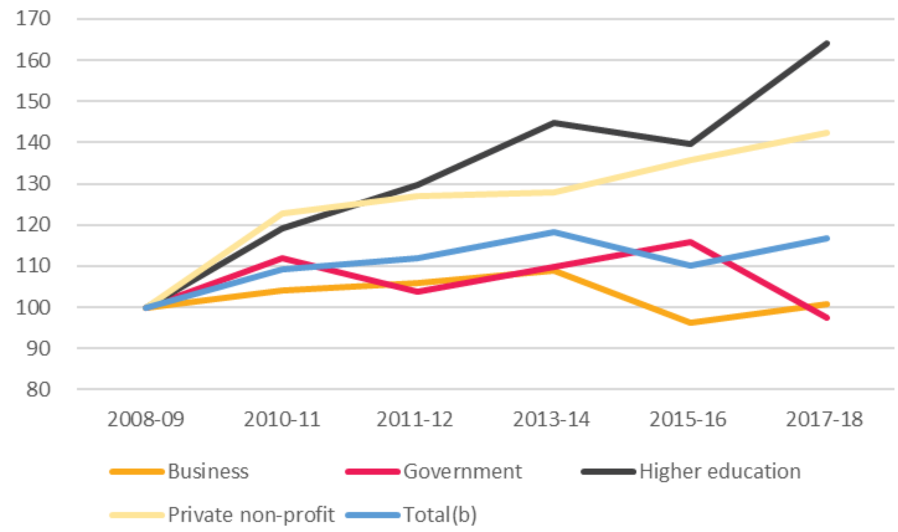
To enable comparisons of South Australia's R&D environment with other states and other jurisdictions, measures of intensity are required to provide fair comparisons. R&D intensity refers to the relative level of R&D activity within the economy, such as the ratio of R&D expenditure to GSP.

South Australia has relatively lower levels of business and private non-profit expenditure on R&D than Australia as a whole, and higher levels of government expenditure in R&D (discussed in detail further in this section).

In South Australia for the most recent year for which data is available, governments spent $455 million on R&D, universities spent $827 million and businesses spent $798 million.[43]

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

*Figure 3.8: Change in R&D expenditure by type, Australia, Index (2008-09 = 100)*



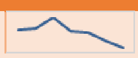
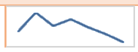
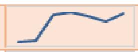
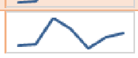

*Source: ABS 8104.0*

Higher education expenditure on R&D has been the fastest growing expenditure category since 2008-09, growing on average 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 of private non-profit expenditure on R&D occurs in South Australia.

### 3.2.1 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[44], only the total expenditure is available by state. Therefore, much of the data presented in this section will be at the national level and may not necessarily be representative of South Australia.

*Table 3.10: 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 |  |

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

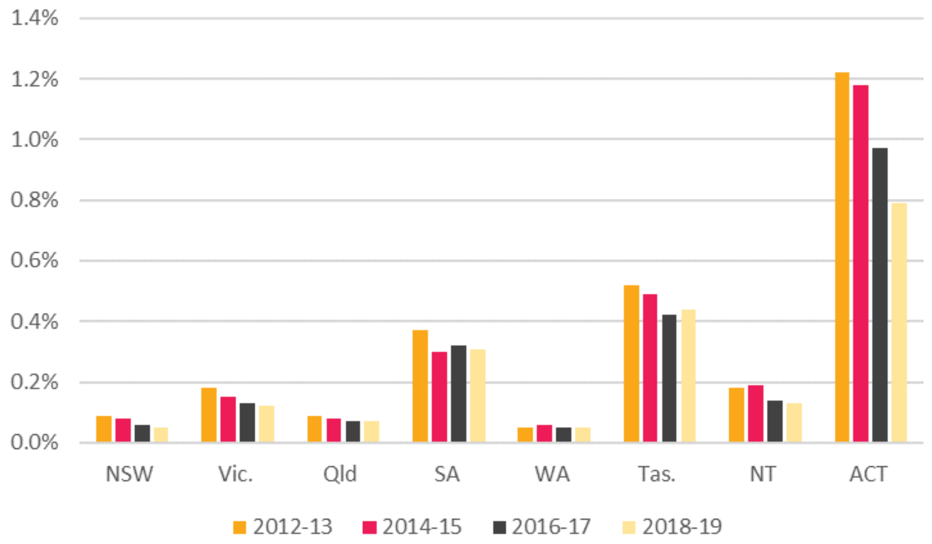
| Location | 2006–07 | 2008–09 | 2011–12 | 2012–13 | 2014–15 | 2016–17 | 2018-19 | Trend |
|---|---|---|---|---|---|---|---|---|
| Victoria | 528 | 555 | 586 | 590 | 549 | 529 | 544 |  |
| Western Australia | 98 | 137 | 113 | 117 | 140 | 125 | 138 |  |
| **Total** | **2,046** | **2,252** | **2,426** | **2,345** | **2,257** | **2,139** | **2,110** |  |

*Source: ABS 8109.0*

In 2018-19, approximately 16 per cent of Australian Government expenditure on R&D occurred in South Australia, with only Victoria having a higher share of Australian Government expenditure. 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.

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

*Figure 3.9: 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.

Ninety per cent of Australian Government expenditure on R&D is on current expenditure, with labour costs representing over half of expenditure. A further one-third of expenditure is on non-capital purchases of materials, supplies, equipment and services to support R&D.

The Australian Government's largest investment in R&D is in universities for the general advancement of knowledge. Other significant investments include industrial production and technology (18 per cent) and health (15 per cent). The data presented in the Science, Research and Innovation Budget Tables differs from the ABS figures used elsewhere in this chapter as it includes all Australian Government funding (and tax concessions), while the ABS data only includes expenditure on R&D that is performed by the Australian Government. For example, expenditure by universities funded by the Australian Government is included in the Science, Research and Innovation Budget Tables as Australian Government expenditure, but is included in HERD in the ABS data.

*Table 3.11: 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** |

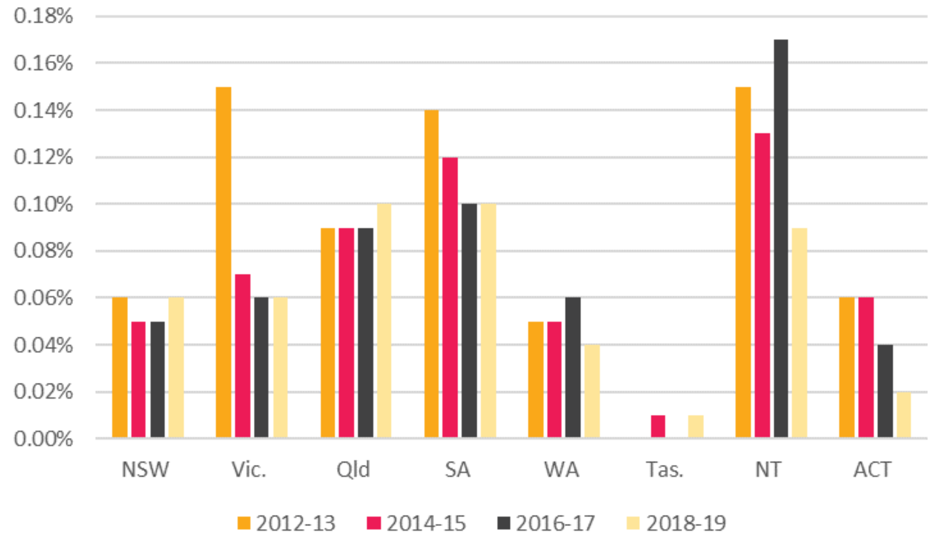
*Source: Department of Industry, Innovation and Science, 2019-20 Science, Research and Innovation Budget Tables.*

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). Expenditure on education has almost doubled over this period but 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).

### 3.2.2 State government

The ABS publish state and local government expenditure on R&D by location of activity, rather than expenditure by each state government. This means that expenditures by the South Australian Government on research occurring outside of South Australia are not counted in the South Australian total, and expenditures by other states on research that occurs inside South Australia are.

*Figure 3.10: 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 highest of any state in 2018-19. However, 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.

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

The South Australian Government does not publish or record its R&D expenditures. The Commission has asked South Australian Government agencies to identify and report their expenditures on R&D. Identified expenditures by agency over the past five years are presented in Table 3.12. 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 3.12: 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 |

| Agency | 2015-16 | 2016-17 | 2017-18 | 2018-19 | 2019-20 |
|---|---|---|---|---|---|
| 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.

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).

Most agencies' expenditure is largely targeted on 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 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.

Due to a lack of historical reporting, the Commission has been unable to determine trends in the South Australian Government's aggregate support for R&D.

### 3.2.3 Higher education

In 2018, 6.8 per cent, or $827 million, of Australia's higher education expenditure on R&D occurred in South Australia.

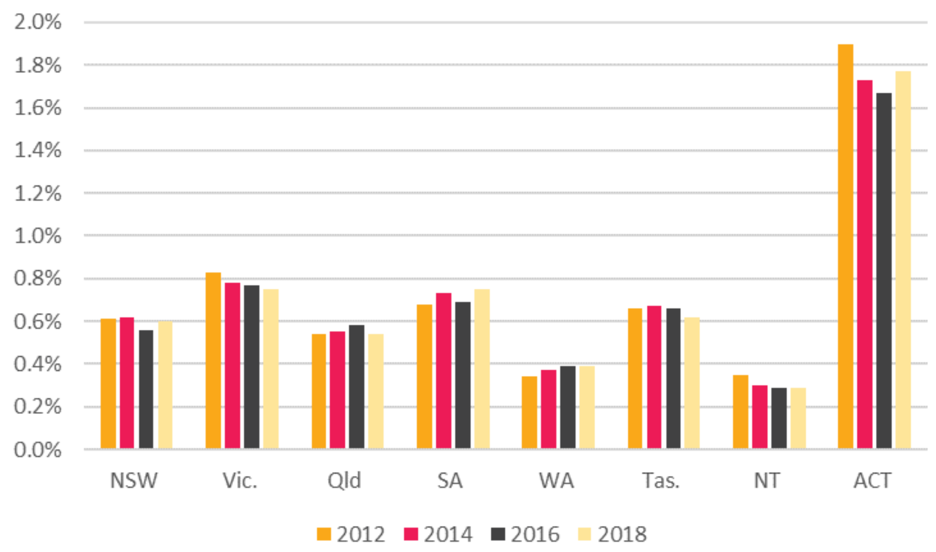
*Table 3.13: Higher Education expenditure on R&D, by location, $m and per cent growth*

| State | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | CAGR[45] (%) |
|---|---|---|---|---|---|---|---|
| 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*

However, this expenditure has been growing by less than the national average and as a result South Australia's share of national expenditure has fallen from 7.4 per cent in 2008.

*Figure 3.11: Higher Education expenditure on R&D, by location, per cent of GSP*




*Source: ABS 8111.0*

When compared to the size of the state economy, 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.

*Table 3.14: 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 | |

[45] Compound annual growth rate (CAGR)

| Field of research | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | Trend |
|---|---|---|---|---|---|---|---|
| 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** | |

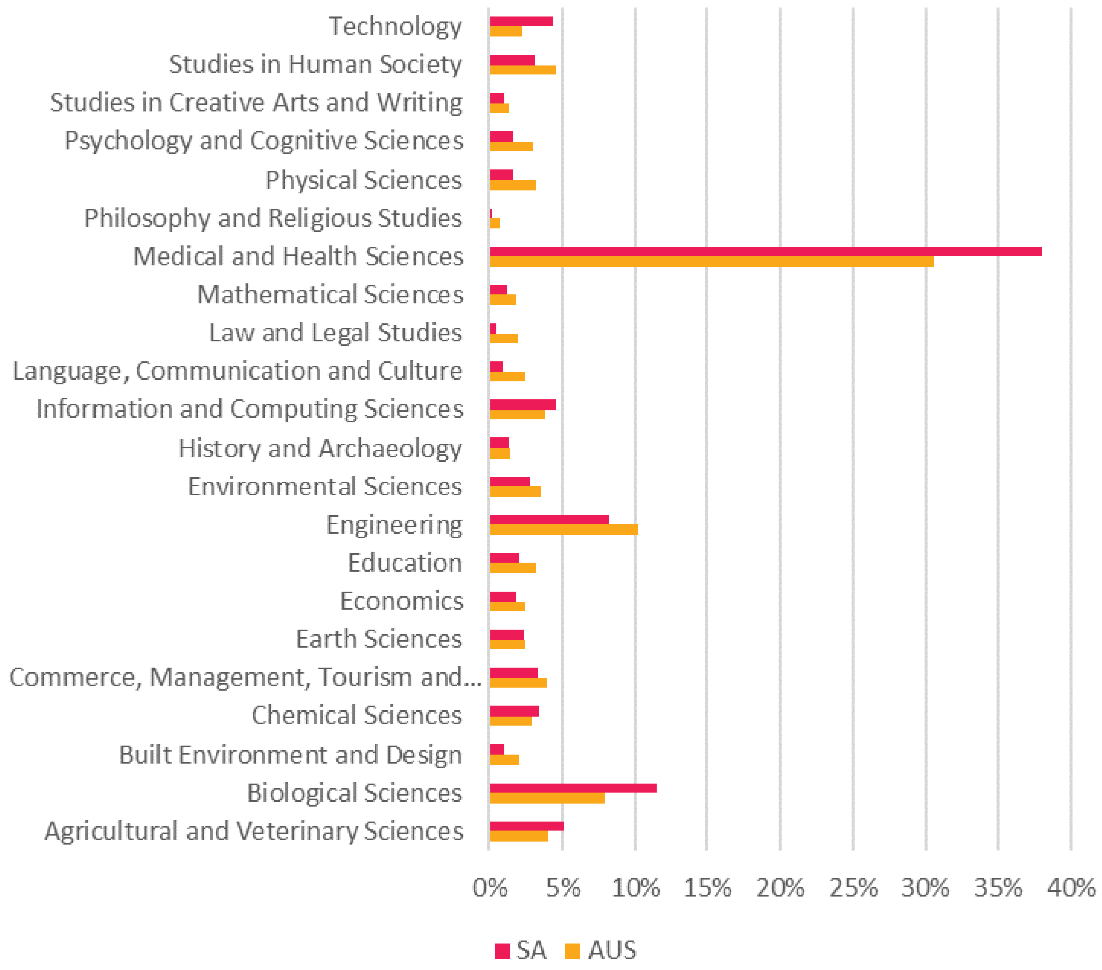
*Source: ABS 8111.0*

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) and language, communication and culture (13.7 per cent).

*Figure 3.12: 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.

*Table 3.15: 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 | |

| Socio-economic objective | 2008 | 2010 | 2012 | 2014 | 2016 | 2018 | Trend |
|---|---|---|---|---|---|---|---|
| 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** | |
| 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 3.16 presents the expenditure by type of activity for both the South Australian and Australian higher education sectors in 2018.

*Table 3.16: Higher education expenditure on R&D by type of activity, by location, 2018*

| | South Australia | | Australia | |
|---|---|---|---|---|
| **Type of Activity** | $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.

### 3.2.4 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.

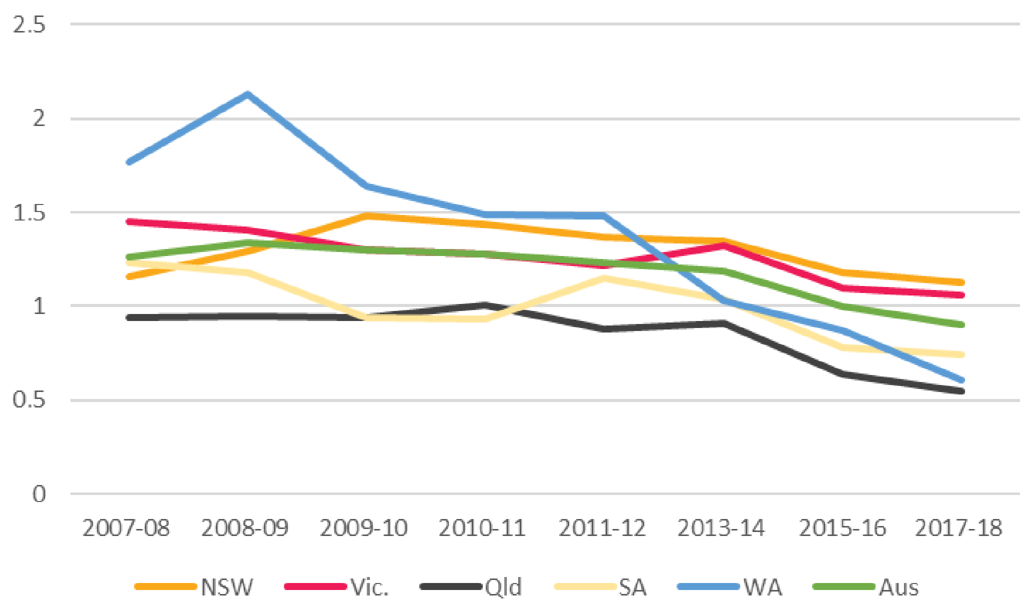
*Table 3.17: Business expenditure on R&D, by location, $m*

| 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 | 5362.1 | 6078.5 | 6345.6 | 6382.7 | 6651.6 | 6420.9 | 6823.0 | |
| Northern Territory | 101.5 | 122.6 | 149.4 | 137.7 | 218.9 | 72.2 | 31.4 | |
| Queensland | 2496.7 | 2364.1 | 2679.0 | 2498.7 | 2699.8 | 1955.6 | 1912.3 | |
| South Australia | 937.7 | 791.8 | 842.6 | 1057.7 | 1003.8 | 774.3 | 798.0 | |
| Tasmania | 137.3 | 115.6 | 145.1 | 164.1 | 147.4 | 184.1 | 176.0 | |
| Victoria | 4183.6 | 3880.0 | 4119.2 | 3978.1 | 4623.1 | 4275.3 | 4544.5 | |
| Western Australia | 3638.0 | 2968.9 | 3265.3 | 3584.9 | 2732.2 | 2082.2 | 1592.3 | |
| Overseas | 340.9 | 352.0 | 373.7 | 430.7 | 628.6 | 805.0 | 1339.4 | |
| **Total** | 17291.2 | 16759.6 | 18006.9 | 18321.3 | 18849.4 | 16659.3 | 17437.6 | |

*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 3.13: 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. However, 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.

*Table 3.18: Business expenditure on R&D, by industry, by location, 2017-18*

| Industry | South Australia $'000 | Total expenditure on R&D $'000 | Share of national % | Share of SA total % |
|---|---|---|---|---|
| Agriculture, Forestry and Fishing | 24,381 | 313,596 | 7.8 | 3.1 |
| Mining | 65,226 | 1,049,805 | 6.2 | 8.2 |
| Manufacturing | 197,247 | 4,599,464 | 4.3 | 24.7 |
| Electricity, Gas, Water and Waste Services | 25,784 | 353,020 | 7.3 | 3.2 |
| Construction | | 349,164 | | |
| Wholesale Trade | 53,254 | 930,532 | 5.7 | 6.7 |
| Retail Trade | 10,230 | 242,204 | 4.2 | 1.3 |
| Accommodation and Food Services | | 37,838 | | |
| Transport, Postal and Warehousing | | 120,423 | | |
| Information Media and Telecommunications | 14,230 | 610,052 | 2.3 | 1.8 |
| Financial and Insurance Services | 63,441 | 2,846,990 | 2.2 | 8.0 |
| Rental, Hiring and Real Estate Services | 25,484 | 193,815 | 13.1 | 3.2 |
| Professional, Scientific and Technical Services | 275,245 | 5,113,123 | 5.4 | 34.5 |
| Administrative and Support Services | | 166,800 | | |
| Public Administration and Safety | | 21,889 | | |
| Education and Training | | 50,604 | | |
| Health Care and Social Assistance | 14,081 | 140,823 | 10.0 | 1.8 |
| Arts and Recreation Services | 0 | 122,788 | 0.0 | 0.0 |
| Other Services | 18,168 | 174,653 | 10.4 | 2.3 |
| **Total** | **797,988** | **17,437,585** | ***4.6*** | ***100.0*** |

*Source: ABS 8104.0*

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.

More disaggregated data on the types of business R&D expenditure is not available at the state level. Accordingly, the remaining data presented in this section is at the national level.

*Table 3.19: 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.

*Table 3.20: Business expenditure on R&D, by socio-economic objective, Australia, $m*

| Socio-economic objective | 2007-08 | 2008-09 | 2009-10 | 2010-11 | 2011-12 | 2013-14 | 2015-16 | 2017-18 |
|---|---|---|---|---|---|---|---|---|
| **Economic Development** | | | | | | | | |
| Economic Framework | 31 | 33 | 24 | 26 | 21 | 18 | 8 | 59 |
| Animal Production and Animal Primary Products | 108 | 132 | 156 | 209 | 166 | 216 | 376 | 425 |
| Plant Production and Plant Primary Products | 179 | 175 | 244 | 284 | 302 | 401 | 342 | 389 |
| Transport | 384 | 465 | 452 | 442 | 438 | 432 | 316 | 285 |
| Construction | 903 | 1,128 | 1,026 | 1,199 | 934 | 855 | 548 | 554 |
| Mineral Resources (excl. Energy Resources) | 2,189 | 2,662 | 1,875 | 2,213 | 2,742 | 2,054 | 1,259 | 1,034 |
| Energy | 2,096 | 2,700 | 2,716 | 2,569 | 2,361 | 2,166 | 1,412 | 959 |
| Information and Communication Services | 1,927 | 1,965 | 1,621 | 1,863 | 1,836 | 2,799 | 2,965 | 3,382 |
| Commercial Services and Tourism | 1,715 | 2,509 | 3,282 | 3,403 | 3,809 | 3,528 | 3,580 | 3,002 |
| Manufacturing | 4,643 | 4,567 | 4,394 | 4,694 | 4,563 | 4,902 | 4,419 | 4,910 |
| **Society** | | | | | | | | |
| Cultural Understanding | 14 | 17 | 14 | 12 | 2 | 6 | 1 | 5 |
| Law, Politics and Community Services | 13 | 12 | 14 | 39 | 56 | 46 | 32 | 68 |
| Education and Training | 26 | 38 | 45 | 46 | 57 | 113 | 125 | 187 |
| Health | 402 | 437 | 434 | 500 | 564 | 784 | 850 | 1,592 |
| **Other** | | | | | | | | |
| Expanding Knowledge | 5 | 10 | 15 | 19 | 44 | 50 | 25 | 51 |
| Environment | 125 | 182 | 227 | 259 | 229 | 237 | 213 | 209 |
| Defence | 287 | 259 | 221 | 231 | 197 | 243 | 188 | 325 |
| **Total** | **15,047** | **17,291** | **16,760** | **18,007** | **18,321** | **18,849** | **16,659** | **17,438** |

*Source: ABS 8104.0*

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 the purposes of 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).

### *Industry Structure and Composition*

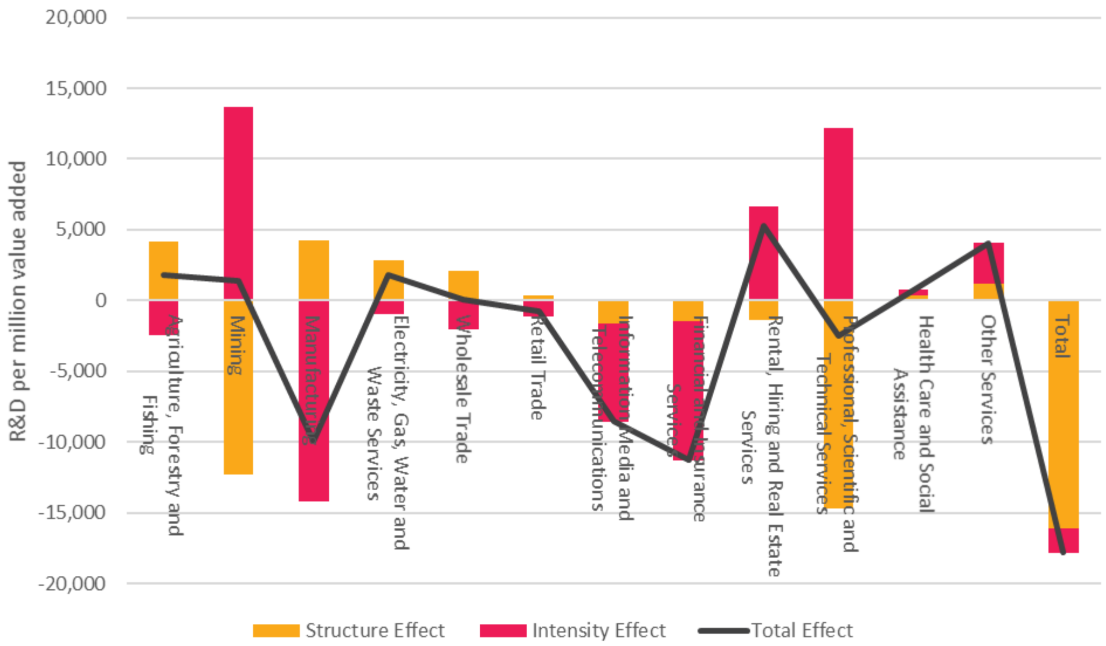
In South Australia 98 per cent of all business are small with fewer than 20 employees. Over 60 per cent of businesses do not employ any staff, and only a small percentage have a turnover greater than $5 million per annum. Crucially, the percentage of large businesses in the state is roughly half the 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 of these 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. Several different methodologies have been used to decompose changes of R&D intensity into an effect of industry structure and industry intensity,[46] but the Commission has applied the Logarithmic Mean Divisia Index method of Sato[47] and applied business R&D expenditure by the OECD.[48]

In comparing South Australia's R&D intensity to that of Australia in 2017-18, South Australia had approximately $17,800 less business R&D expenditure 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. The contribution of each effect by industry sector is presented below in Figure 3.14.

*Figure 3.14: Sectoral contribution to differences between South Australia's and Australia's Business R&D intensity, 2017-18*



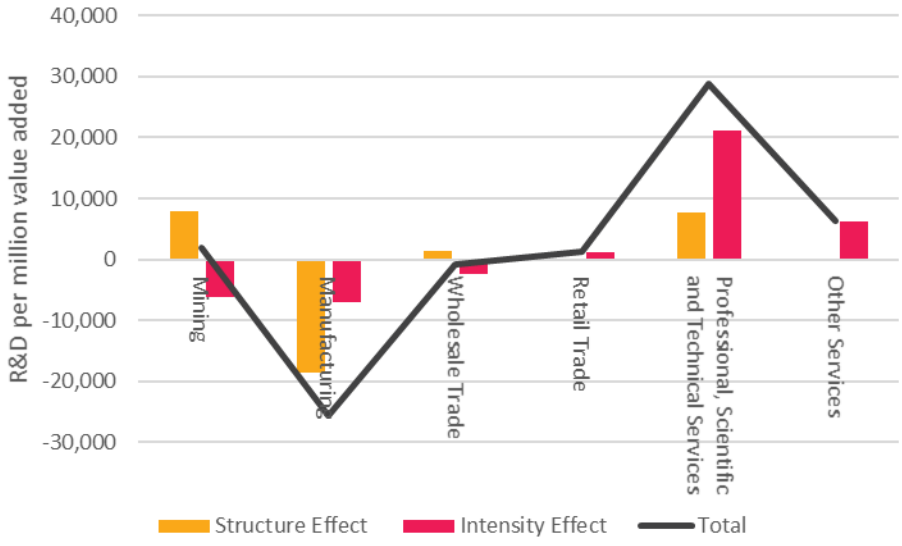

*Source: ABS 5204.0, ABS 5220.0, ABS 8104.0 and SAPC calculations*

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 had higher levels of R&D expenditure in agriculture, forestry and fishing 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.

[46] 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.
[47] K Sato, 'The Ideal Log-Change Index Number' (1976) 58, *Review of Economics and Statistics*, 223-228.
[48] V Koutsogeorgopoulou and T Park, *Boosting R&D outcomes in Australia* (2017), OECD Economics Department Working Papers, No. 1391. p.10.

This methodology also allows, in principle, for examination of changes in business R&D expenditure over time. Data limitations preclude this for the South Australian economy 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.

*Figure 3.15: 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 demonstrated in Figure 3.14 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.

### 3.2.5 Private non-profit

Only 2.3 per cent of private non-profit expenditure on R&D occurred in South Australia in 2016-17, with almost half of expenditure in Australia taking place in Victoria.

*Table 3.21: Private non-profit expenditure on R&D, by location and national share, 2016-17*

| Location of expenditure | $'000 | Per cent of national |
|---|---|---|
| New South Wales | 330,801 | 31.8 |
| Victoria | 515,236 | 49.6 |
| Queensland | 51,432 | 4.9 |
| South Australia | 23,654 | 2.3 |
| Western Australia | 77,119 | 7.4 |
| Tasmania | - | - |
| Northern Territory | - | - |
| Australian Capital Territory | 8,296 | 0.8 |
| Overseas | 28,122 | 2.7 |

*Source: ABS 8109.0*

Expenditure in this sector focusses on research expected to lead to useful discoveries in specified areas, with only 3.7 per cent of expenditure occurring on pure basic research.

*Table 3.22: Private non-profit expenditure on R&D, by type of activity, Australia, 2016-17*

| Type of activity | $'000 | % |
|---|---|---|
| Pure basic research | 38,849 | 3.7 |
| Strategic basic research | 437,558 | 42.1 |
| Applied research | 370,232 | 35.6 |
| Experimental development | 193,143 | 18.6 |

*Source: ABS 8109.0*

## 3.4 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 3.23: 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 spread of the COVID-19 virus and a significant decrease in 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, both state and commonwealth, than the national average.

The South Australian Government's main R&D expenditures are 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.

**Information request 3.1**

The Commission seeks further information on the following issues:

- Is the Commission's characterisation of R&D expenditure in South Australia accurate?
- Are there any sources of funding for R&D or areas of expenditure that require further examination?
- What other sources of data are available that have not been used by the Commission?
- Why does South Australia receive such a small portion of private non-profit R&D?

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

## 4.1 Introduction

The terms of reference provided to the Commission define the scope of R&D as all sectors of the South Australian economy. Given the data and analytical limitations, the Commission has focused its analysis on:

- engagement in R&D by and with the business sector in South Australia and comparable benchmarks with other jurisdictions;
- types of activity and the implications for output; and
- outputs of the state's research effort as measured by intellectual property protection and the effect of research institutions on the stock of knowledge in the South Australian economy.

In summary, the Commission has found that research performance by business in SA is broadly in line with expectations, having regard to the industry mix in the state's economy, with businesses in the state spending about $800 million in 2017-18. 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.

Collaborations of the basic research sector with industry are not well integrated for both the higher education and industry sectors and the share of venture capital funds which comes to South Australia is low.

In the higher education sector, there are a few research fields in South Australia that 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 population share between 2006 and 2018. South Australian universities were host to 6.5 per cent of Australia's higher education total staff PYE devoted to R&D.

The Commission's analysis in this chapter focuses on the relative performance of South Australia compared to other jurisdictions on aspects of R&D that are considered critical for economic growth as a subset of overall observable growth for the state.

## 4.2. R&D Performance in South Australia

### 4.2.1. National accounting perspective

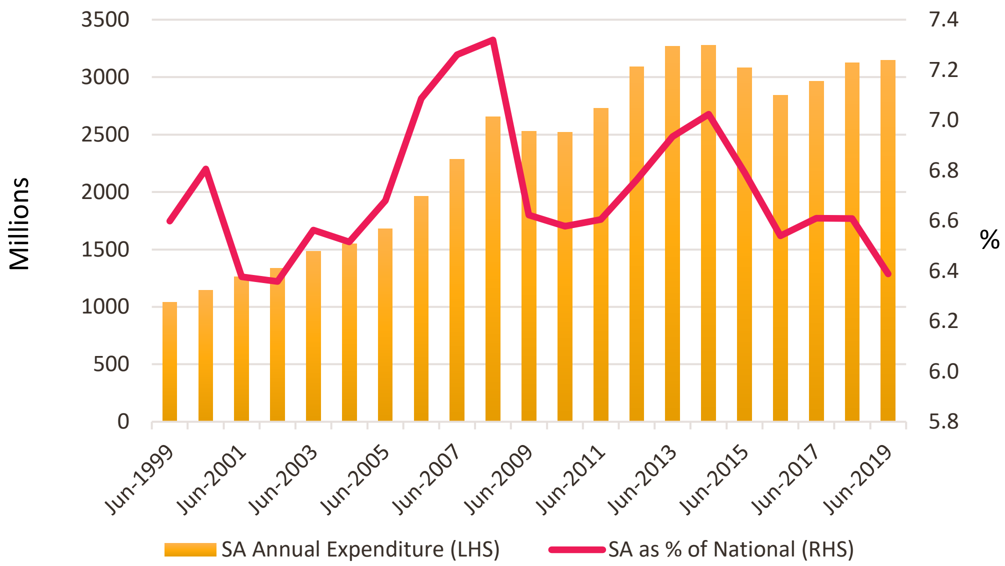
The 2008 International System of National Accounts treats the acquisition of R&D services by a firm from the buyer's perspective, in most cases, as an acquisition of an R&D asset[49]. Thus, domestic sales of R&D output are no longer offset by intermediate consumption, on

[49] 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.

the part of the purchaser, in the calculation of GDP causing output, as well as the capital stock, to increase.[50] [51]

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-year period from 6.6 per cent to 6.4 per cent.

*Figure 4.1: Intellectual property capital formation (current prices), South Australia*

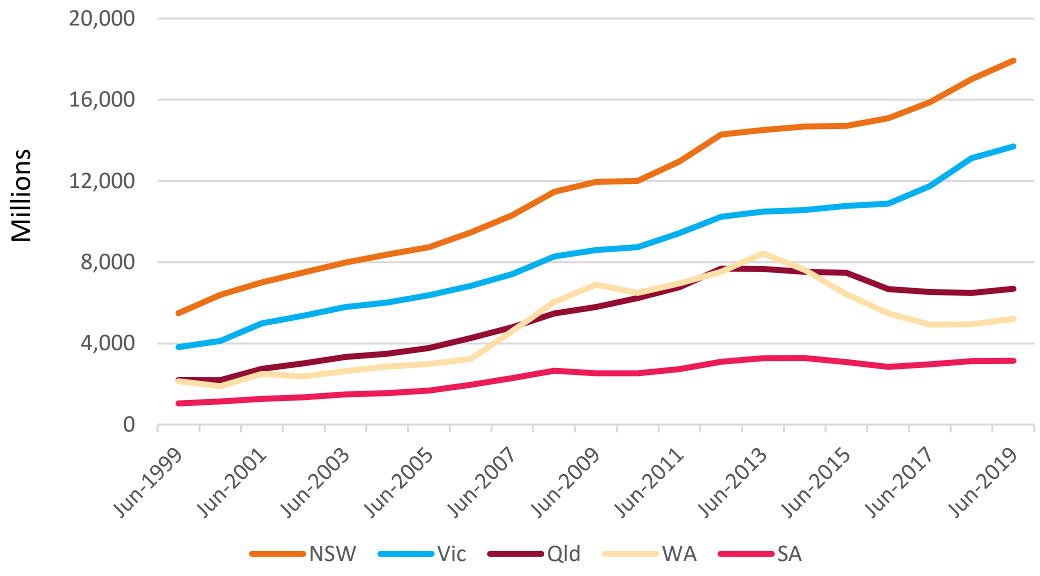



*Sources: ABS Catalogue No. 5220.0, Australian National Accounts: State Accounts, 2018-19, Table 24, South Australia capital stock by type of asset and ABS Catalogue No. 5204.0, Australian System of National Accounts, 2018-19, Table 56 capital stock by type of asset*

South Australia's performance is mixed compared with other jurisdictions. The growth in IP capital formation has been quite 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). Western Australia's IP capital formation has shown relatively lower absolute growth.

[50] 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.
[51] 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 4.2: Intellectual property capital formation (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 spending

The Commission investigated whether SA businesses, compared to those nationally, 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 dataset that was most appropriate and useful to understand this issue is Commonwealth business longitudinal data.

The ABS undertook an analysis for the Commission of 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. [52]

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.

[52] 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.

The data indicates that eligible expenditure on R&D by South Australian companies over the period 2011-12 to 2017-18 comprised 3.2 per cent of the national total with R&D taxation incentive offsets claimed by South Australian companies comprising 4.7 per cent, with both proportions being somewhat less than the state's population share. (The numbers in individual years are too volatile and greatly affected by the previous scheme to enable 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 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 |
| 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 (1.9 per cent) and Western Australia (1.6 per cent).

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, total expenditure is much lower than population share, the important conclusion is that small businesses in South Australia ‘punch above their weight’ in terms of 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 transition of start-up and small business 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 |
| **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.[53]

The results showed significantly different probabilities across industries, business sizes and states and territories (The results are provided in Appendix 4.).

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 R&D expenditure is highest for the mining industry. South Australia’s gross domestic product by industry share with a national comparison is shown in Table 4.3.

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

*Table 4.3: Share of gross state/domestic product by industry (per cent)*[54]

| | South Australia 2018-19 | Australia 2018-19 |
|---|---|---|
| Agriculture, forestry & fishing | 4.7 | 2.1 |
| Mining | 3.4 | 9.5 |
| Manufacturing | 6.0 | 5.6 |
| Electricity, gas, water & waste services | 3.7 | 2.5 |
| Construction | 7.4 | 7.5 |
| Wholesale trade | 4.2 | 3.7 |
| Retail trade | 4.8 | 4.1 |
| Accommodation & food services | 2.5 | 2.3 |
| Transport, postal & warehousing | 4.1 | 4.6 |
| Information media & telecommunications | 1.9 | 2.2 |
| Financial & insurance services | 7.6 | 8.7 |
| Rental, hiring & real estate services | 2.4 | 3.0 |
| Professional, scientific & technical services | 4.8 | 6.6 |
| Administrative & support services | 2.8 | 3.4 |
| Public administration & safety | 5.5 | 5.2 |
| Education & training | 5.8 | 4.7 |
| Health care & social assistance | 9.8 | 7.0 |
| Arts & recreation services | 0.6 | 0.8 |
| Other services | 2.1 | 1.8 |
| **Total**[55] | **100.0** | **100.0** |

*Source: ABS, Australian National Accounts: State Accounts, Cat. No. 5220.0*

Industry structure also provides some explanation for the level of business R&D expenditure in South Australia (see Table 4.3). That is, some industries are under-represented in the South Australian economy in comparison to Australia, such as mining and professional and technical services, are more likely to undertake R&D. Other industries such as agriculture, fisheries and forestry are less likely to undertake R&D.

The results also indicate that companies belonging to larger business sizes 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, with younger firms 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 lower number of medium and large size businesses here compared with that nationally.

[54] Share represents industry gross value added as a proportion of Gross State/Domestic Product. Gross value added is the value of output at basic prices minus the value of intermediate consumption at purchasers' prices. The shares presented here are based on current price estimates of gross value added.

[55] Sum of individual components does not add up to 100 per cent as total Gross State/Domestic Product includes gross value added associated with ownership of dwellings, taxes less subsidies on products, and statistical discrepancy (all not shown).

### 4.2.3. Patents

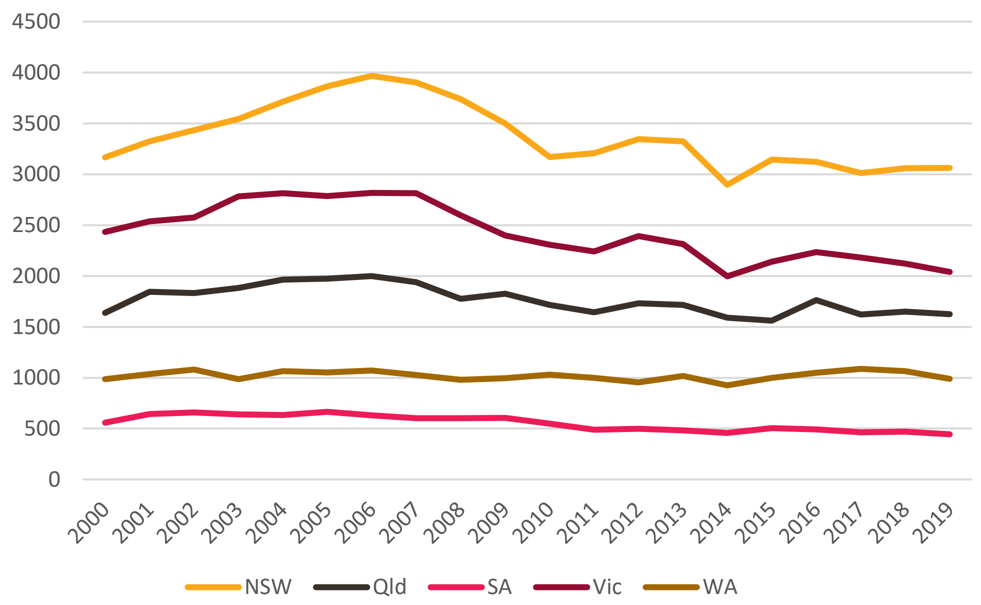
A patent represents a minimal amount of invention which has passed both the scrutiny of patent office assessors and the test of the organisation of the investment of effort and resources into the development of the product or process. This indicates a non-negligible expectation of the patent's utility and marketability. Patents as an indicator of inventive activity need to consider 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[56].

From the perspective of analysis, a patent document contains useful information besides the name of the organisation(s) or the individual(s) to which the patent right may have been assigned. It also contains information on the type of industry and technology, cites previous patents and associated scientific publications, and describes the invention. The Commission is still investigating the possible use of patent statistics to provide more in-depth analysis of R&D performance in SA.

The Commission uses state-based information of total standard patent applications as a proxy for relative outputs of inventive activity.

Figure 4.3 depicts 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 4.3: Annual patent applications 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.)*

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

Data for South Australian IP outputs against national outputs for trademarks and designs is 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 assist to some degree to identify collaborations by indicating the proportion of joint patent applications of 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[57].

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. 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 4.4: Proportion of standard patent applications with joint applicants, 2000-19*

| Jurisdiction | Proportion of patent filing applications collaborating with another party (%)[58] |
|---|---|
| **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[59].

[57] 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).
[58] Note that as joint applications can include international applicants that the patent data here differs from that discussed in Chapter 4, which exclusively analysed patents generated by Australian companies and individuals.
[59] A Valero and J Van Reenen, 'The Economic Impact of Universities: Evidence from Across the Globe'(2019) 68 *Economics of Education Review*, 53-67.

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 assessment exercise; and
- protection and commercialisation of IP as measured by numbers of patents and numbers of licenses granted, as well as income from these commercialisation activities.

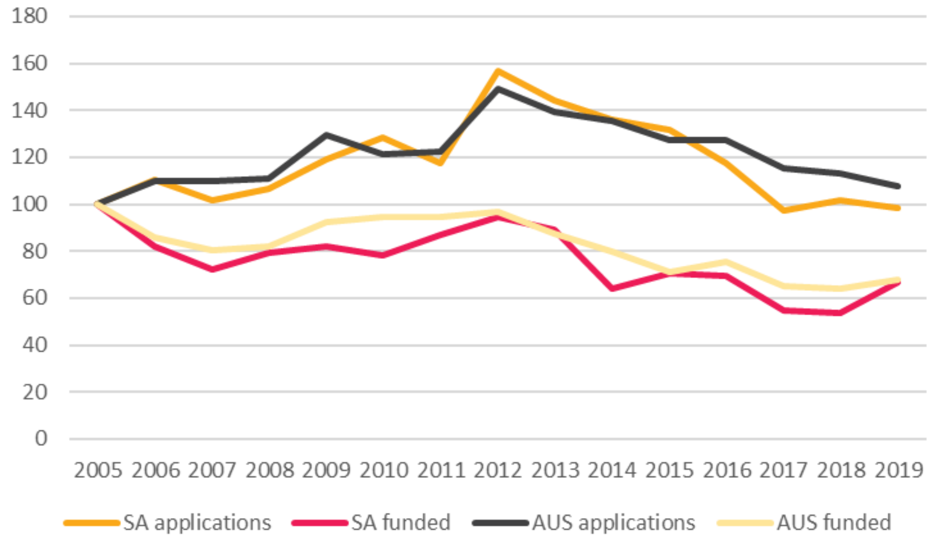
Other metrics, such as the number of publications with external/international authors, are also used for measurement purposes. The engagement and impact assessment and protection and commercialisation of IP measures are discussed in section 6.2.

***Grant funding and success rates***

The total amount of ARC funding provided to universities has declined since 2014, 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. Factors influencing South Australia's share of ARC funding include the number of applications, the size of grants and the success rate in obtaining grants.

The number of applications funded by the ARC has been declining both nationally and in South Australia since 2015, as shown in Figure 4.4.

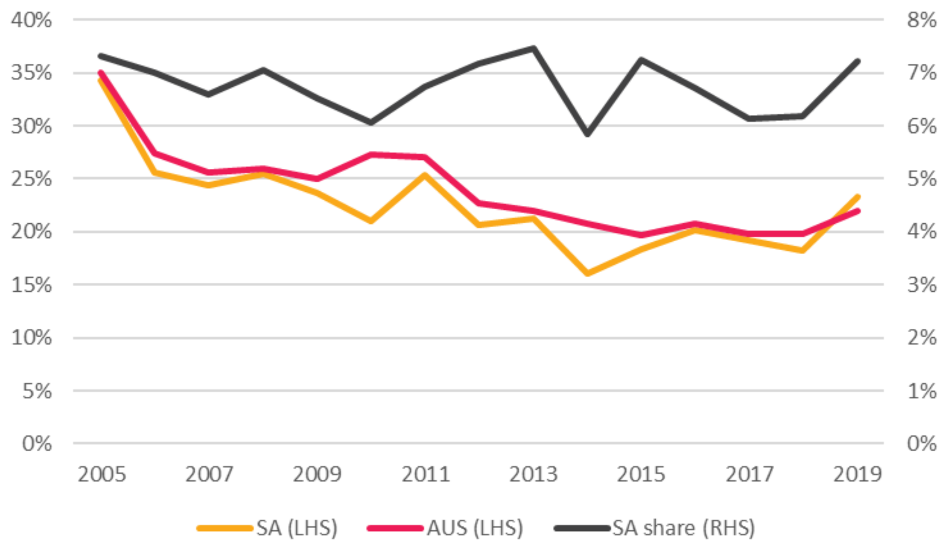
*Figure 4.4: Number of applications for ARC funding and number of grants awarded, SA and AUS, Index 2005=100*




*Source: ARC data, SAPC calculations*[60]

The number of grants awarded by the ARC per year has declined by 32 per cent nationally since 2005. 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.

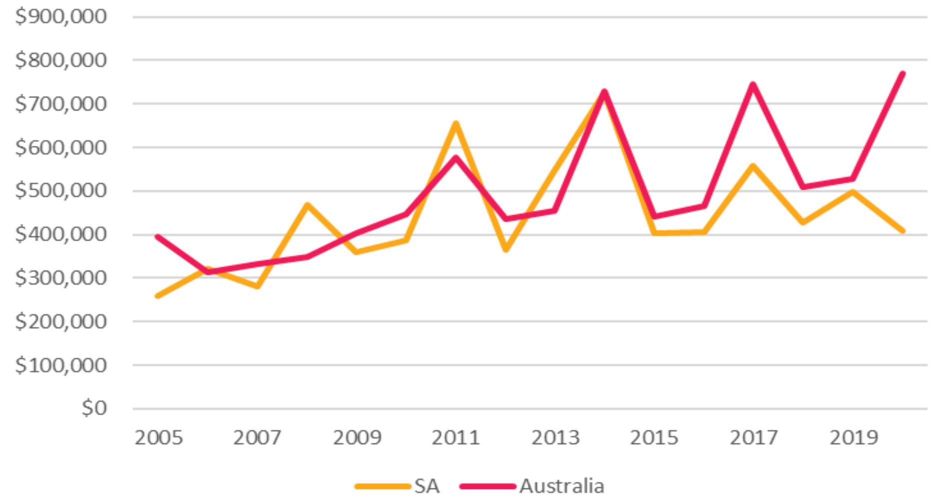
*Figure 4.5: ARC proportion of successful applications, SA and AUS, annually, 2005 to 2019*




Source: ARC data, SAPC calculations

[60] 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 commences.

*Figure 4.6: 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 likely a result of South Australia not being awarded any new funding through the ARC Centres of Excellence program since 2014 (although South Australia has submitted only one application in this period).

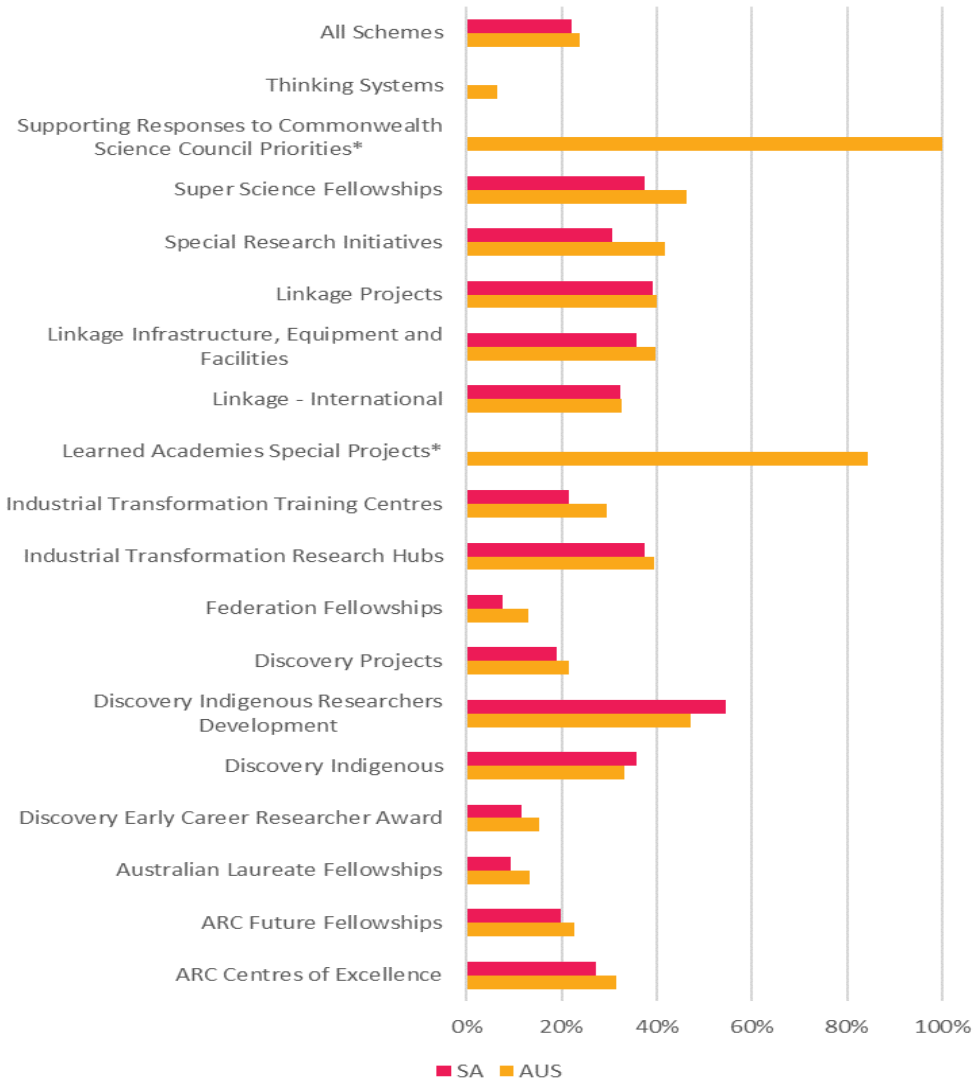
Since 2005, South Australian universities have submitted 6.7 per cent of applications and received 6.1 per cent of funding approved by the ARC. This is despite having between seven and nine per cent of Australia's academic staff PYE devoted to research over this period.

> *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.*[61]

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

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

*Figure 4.7: ARC competitive grants, per cent of applications funded by program, SA and AUS, 2005 to 2020*




*Source: ARC data, SAPC calculations. *no applications from SA universities*

### *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[62]. 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 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.

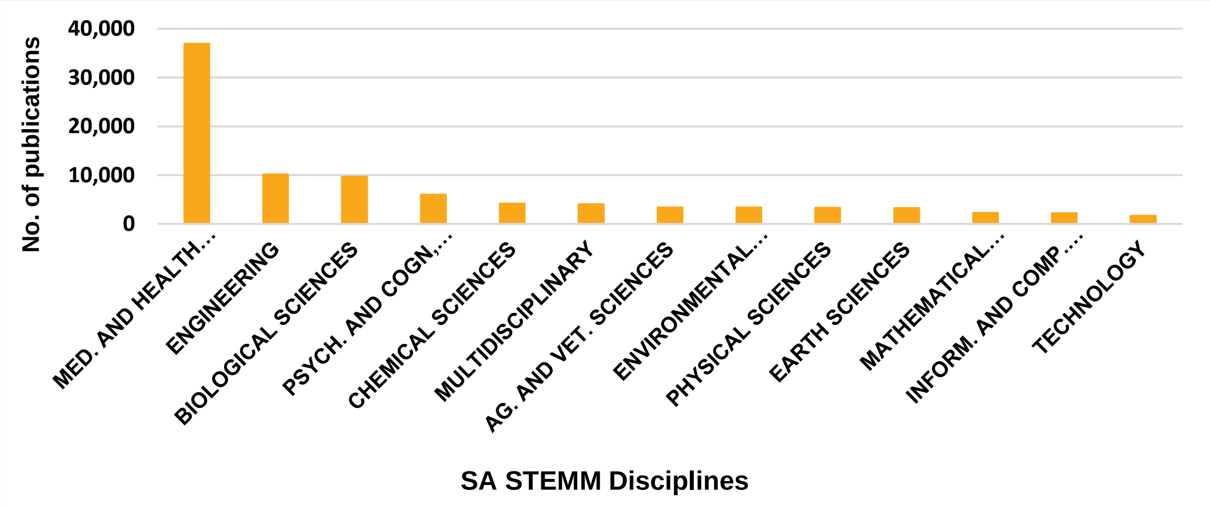
The Commission presents below selected quantity and quality indicators against relevant national and world standards.

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

Analysis by the South Australian Office of the 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 4.8 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, with engineering and biological sciences contributing 11.2 and 10.7 per cent respectively.

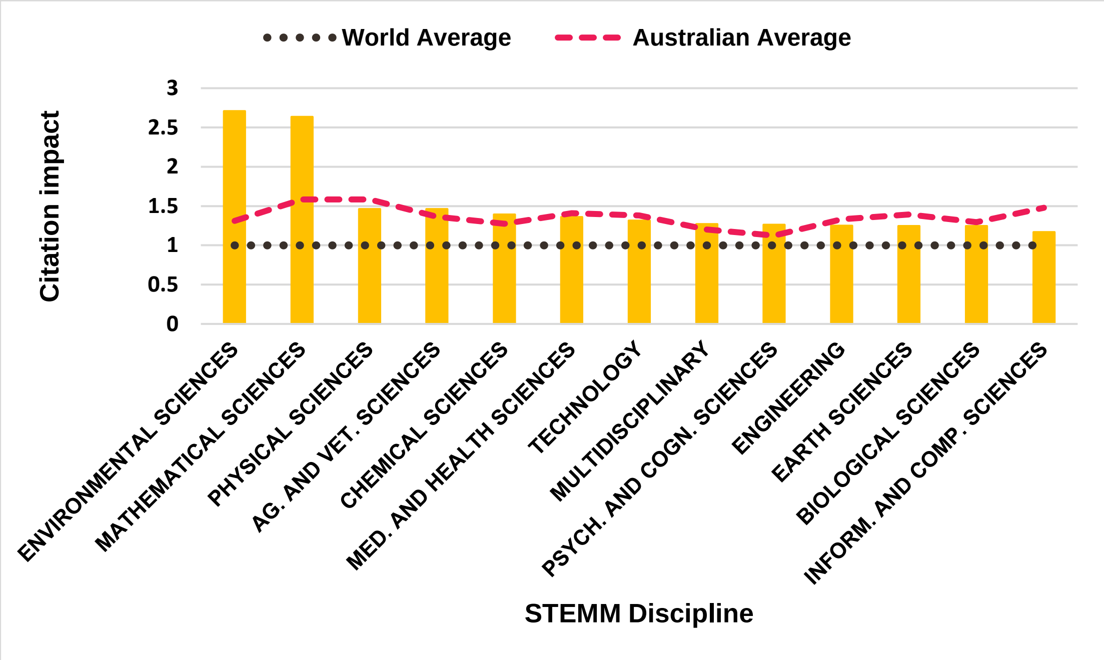
*Figure 4.8: Volume of STEMM research publications by STEMM Discipline: SA, 2009-18*




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

As shown in Figure 4.9, 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.

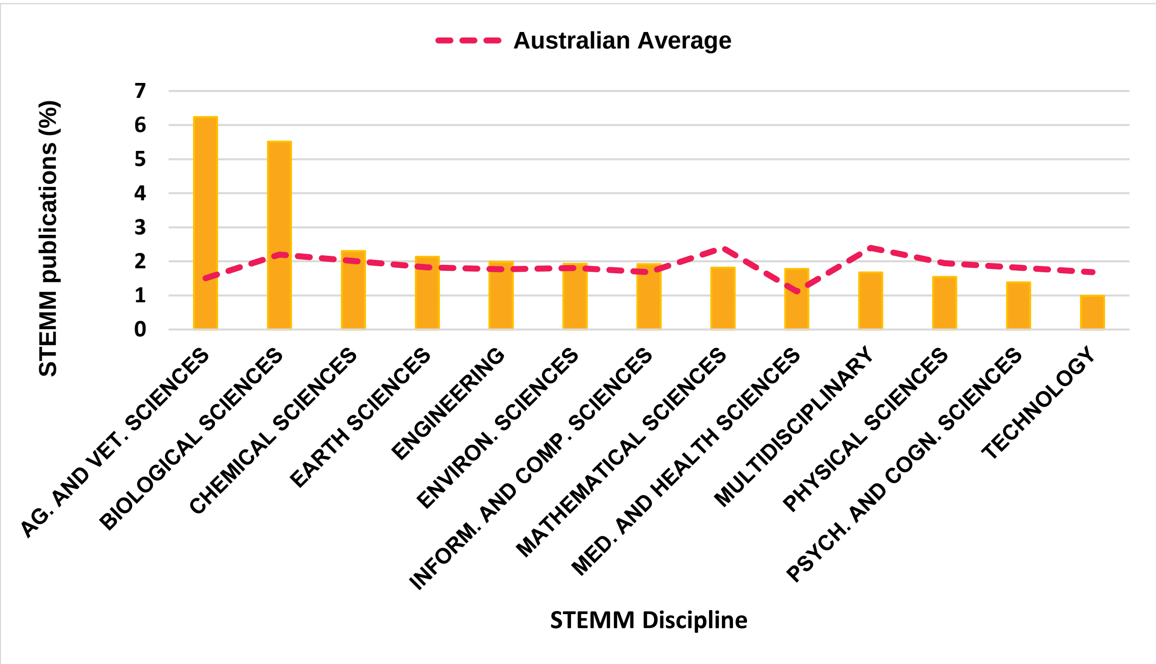
*Figure 4.9: Category normalised citation impact of STEMM publications by STEMM discipline for South Australia, 2009-2018*




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

Figure 4.10 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 4.10: 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*

Table 4.5 presents South Australia's share of Australia's higher education R&D inputs and outputs. The state generally performs well in terms of translating research effort into publication output with high impact. South Australia is above population share of outputs for almost all fields of research apart from studies in creative arts and writing and built environment and design. Caution needs to be exercised in terms of interpreting this data as a productivity measure for the reasons discussed earlier in the chapter relating to differing outputs, non-standard units of labour and proportional relationships between spending and outputs occurring across fields of research.

*Table 4.5: South Australia's share of Australia's higher education R&D inputs and outputs 2010-18 (%)*

| | Inputs | | Outputs | |
|---|---|---|---|---|
| **Field of Research** | Expenditure | Staff | Top 1% | Top 10% |
| Agricultural and Veterinary Sciences | 11.8 | 10.4 | 10.5 | 10.0 |
| Biological Sciences | 7.2 | 9.3 | 9.8 | 10.1 |
| Built Environment and Design | 6.5 | 7.1 | 6.5 | 8.8 |
| Chemical Sciences | 9.8 | 7.3 | 9.3 | 8.1 |
| Commerce, Management, Tourism and Services | 4.7 | 7.1 | 7.6 | 7.0 |
| Earth Sciences | 7.0 | 8.6 | 7.5 | 9.3 |
| Economics | 3.8 | 7.1 | 8.6 | 8.7 |
| Education | 4.2 | 7.7 | 9.5 | 7.9 |
| Engineering | 5.2 | 7.7 | 10.5 | 9.8 |
| Environmental Sciences | 7.6 | 8.1 | 10.6 | 11.0 |
| History and Archaeology | 2.6 | 8.1 | 9.6 | 6.1 |
| Information and Computing Sciences | 7.4 | 5.4 | 9.3 | 9.3 |
| Language, Communication and Culture | 3.6 | 8.0 | 11.3 | 9.8 |
| Law and Legal Studies | 1.7 | 6.5 | 11.3 | 9.8 |
| Mathematical Sciences | 5.2 | 8.2 | 24.3 | 14.6 |
| Medical and Health Sciences | 8.5 | 11.2 | 11.7 | 11.1 |
| Philosophy and Religious Studies | 1.5 | 6.6 | 6.5 | 5.3 |
| Physical Sciences | 4.1 | 6.9 | 18.1 | 11.5 |
| Psychology and Cognitive Sciences | 4.6 | 8.0 | 7.6 | 9.4 |
| Studies in Creative Arts and Writing | 4.6 | 6.5 | 2.2 | 2.8 |
| Studies in Human Society | 5.3 | 7.8 | 11.1 | 10.0 |

*Source: ABS 8111.0, ARC data, Clarivate Analytics, SAPC calculations.*

*Note: the figures likely overstate South Australian outputs as any paper with at least one South Australian co-author is included. Publications refer to articles, reviews and proceedings for all years from 2010 to 2018 with average expenditure and headcount by field aggregated for the years 2010, 2012 and 2018. 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.*

### *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); and
- 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 field 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.[63]

<u>ERA results for South Australian universities</u>

Table 4.6 presents the results for South Australian universities of the ERA assessments conducted in 2010 and in 2018 to enable some comparison in performance over time[64]. The assessments conducted in 2012 and 2015 have not been included. The scale ranges from

[63] 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'.

[64] 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.

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.

*Table 4.6: ERA results for South Australian universities in all research disciplines (2-digit level) for 2010 and 2018*

| Field of Research | Flinders University | | University of Adelaide | | University of South Australia | |
|---|---|---|---|---|---|---|
| | 2010 | 2018 | 2010 | 2018 | 2010 | 2018 |
| Mathematical Sciences | N/A | N/A | 3 | 5 | 3 | 5 |
| Physical Sciences | 2 | 4 | 5 | 5 | N/A | N/A |
| Chemical Sciences | 3 | 3 | 3 | 5 | 5 | 4 |
| Earth Sciences | 3 | 3 | 5 | 5 | N/A | N/A |
| Environmental Sciences | N/A | 3 | 5 | 4 | 4 | 5 |
| Biological Sciences | 3 | 4 | 4 | 5 | 2 | 4 |
| Agricultural and Veterinary Sciences | 3 | 3 | 5 | 5 | N/A | N/A |
| Information and Computing Sciences | N/A | 2 | 3 | 4 | 2 | 3 |
| Engineering | 2 | 3 | 3 | 5 | 3 | 5 |
| Technology | N/A | 4 | N/A | 4 | N/A | N/A |
| Medical and Health Sciences | 3 | 4 | 5 | 5 | 3 | 4 |
| Built Environment and Design | N/A | N/A | 2 | 3 | 3 | 3 |
| Education | 2 | 3 | 1 | 2 | 2 | 3 |
| Economics | 1 | 2 | 3 | 4 | 1 | 2 |
| Commerce, Management, Tourism and Services | 2 | 2 | 2 | 3 | 2 | 4 |
| Studies In Human Society | 3 | 3 | 3 | 3 | 1 | 3 |
| Psychology and Cognitive Sciences | 3 | 4 | 3 | 4 | 2 | 5 |
| Law and Legal Studies | 3 | 3 | 4 | 4 | 3 | 3 |
| Studies in Creative Arts and Writing | 3 | 4 | 5 | 4 | 3 | 3 |
| Language, Communication and Culture | 2 | 3 | 3 | 3 | 3 | 3 |
| History and Archaeology | 2 | 3 | 3 | 4 | 2 | N/A |
| Philosophy and Religious Studies | 2 | 3 | 4 | 4 | N/A | N/A |

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

## 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 Federal 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 start-up businesses.

## 4.4. Conclusions

The Commission has 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.
- The proportion of SA firms undertaking R&D, measured through Commonwealth business longitudinal data, is higher than the national average. This implies the average spend per firm being lower in South Australia reflecting its higher proportion of small firms.
- More South Australian firms, as a proportion of total firms eligible for R&D tax concession, conduct R&D (1.6 per cent) than Australia (1.5 per cent) but proportionately less in WA (1.9 per cent) and Victoria (1.6 per cent). Between 2011-12 and 2017-18, eligible SA firms reported 3.2 per cent of expenditure for R&D and claimed 4.7 per cent of R&D tax concession offsets.
- South Australian firms are more likely (apart from WA) to undertake R&D related expenditure than any other jurisdiction, holding other factors such as business size, industry, location and turnover, constant.
- With respect to public research, publications in South Australia have about the same proportion of total Australian publications as the state's share of the Australian population. The citation impact is predominantly above national and world average as is the proportion of citations in the top 1 per cent of publications. In terms of the top 10 per cent of publication citations, SA is lower than the national average.

The Commission has presented the data that is available to describe R&D performance in SA. The final report will settle on the recommended set of performance measures for the research system. The choice of measures will need to be relevant to the architectural options discussed in Chapter 7. The measures will be used to track performance across all agencies and research system participants.

**Information Request 4.1**

The Commission invites feedback from stakeholders on possible measures of South Australia's performance in R&D, including:

- has the Commission adequately characterised the performance of South Australia's R&D performance, and what could be improved?
- what measures of R&D performance provide meaningful insight into R&D performance?
- how can productivity of R&D be measured and meaningfully interpreted?

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 will be discussed further in Chapter 7. Options for the state government include financial incentives and support for either expenditure, collaboration or inputs such as workforce, access to finance or infrastructure access and use of equipment and facilities.

# 5. Factors affecting R&D performance: capital

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:

- hard infrastructure; and
- access to data and efficiency of collection and acquisition of information in the context of changes in the technology of research methods.

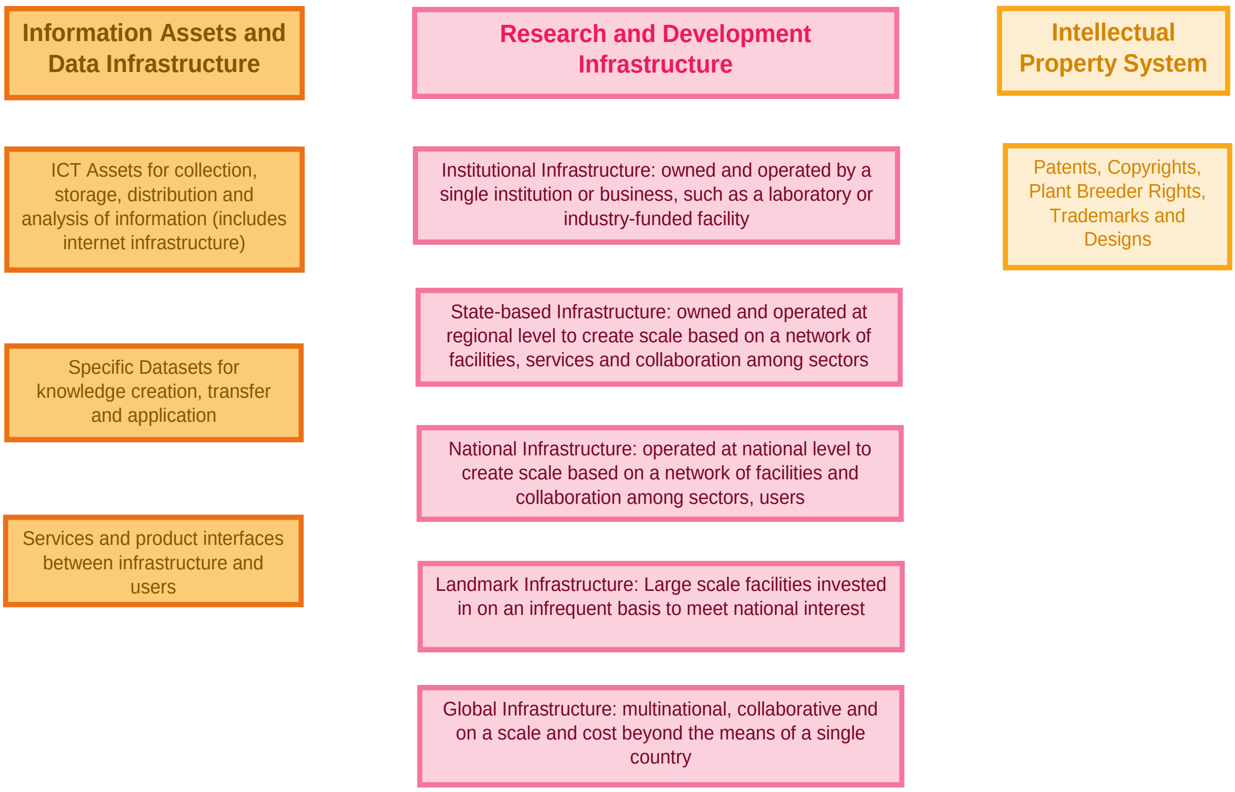
This chapter also focuses on funding available to research organisations and businesses at various stages of the research, development and adoption processes as this was a key theme emerging from the Commission's stakeholder engagement and research.

## 5.1 Infrastructure

### 5.1.1 Introduction

The design, establishment and operation of research and development infrastructure and the ability of this infrastructure to promote collaboration and flow of information is a critical variable in research and development outcomes.

*Figure 5.1: Typology of research infrastructure*




*Source: SAPC*

Research infrastructure in Australia and South Australia is owned, operated and used by a range of organisations in the higher education, government, not-for-profit and business sectors. The types of infrastructure used for R&D can be: small-scale (both physical and service-based); large-scale facilities, both national and international, comprising equipment, buildings and specialised technology; and support infrastructure of information assets and intellectual property (see Figure 5.1).

The most 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 has considerable research capability in primary industries at SARDI.

***State government infrastructure overview***

As part of its evidence gathering, 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 held in agencies is built on varying understandings of R&D; is 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. The information presented in Table 5.1 is a register of all current assets that agencies consider support R&D and has not been filtered or amended by the Commission.

This register of assets has been a significant undertaking for SA Government agencies and has proven to be a valuable exercise. It has the potential to be replicated. This is the subject of a recommendation in the concluding section.

The largest infrastructure investment by state government to support R&D has been building infrastructure associated with innovation and science precincts. The state government has invested $328.8 million in infrastructure at innovation precincts, mainly in the form of buildings (these costs do not include additional expenditures, such as site remediations, which in some cases have been significant).

SARDI's investment in R&D infrastructure has been significant, particularly in R&D equipment. SARDI's investment in R&D equipment constitutes 95.7 per cent of the total state government investment in this type of 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 in the supporting enablers of their work and the translation of knowledge to industry. Quantifying the extent of collaboration with business to access state-owned infrastructure is a difficult exercise and will be explored further by the Commission in the second phase of the inquiry.

*Table 5.1: Register of SA Government R&D infrastructure, estimate of asset value*

| 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*

Access to funding and awareness of research infrastructure are critical variables in the take-up and effective use of research infrastructure.

### 5.1.2 Stakeholder feedback

Stakeholders have emphasised the importance of creating a sustainable innovation ecosystem and the importance of developing linkages between all participants in innovation and science precincts. Awareness of the state's R&D infrastructure and its capabilities amongst the business community has been raised as an issue by some stakeholders. Stakeholders see a key challenge, in extension of this point, is to spread the culture of collaboration and the innovation ecosystem beyond the boundaries of the precincts.

In an interview with the Commission, Deloitte observed that there is potential to increase the level of stewardship by government beyond that of infrastructure custodian. Government as enablers of collaboration between parties and as support in accessing market opportunities would potentially be additional areas of the management of precincts by the state government. Government ownership of the research is also a point of difference that has appeal to investors and tenants.

Some feedback notes the risk of innovation and science precincts overlapping and competing with one another, diluting the small pool of financial, capital and labour resources available to undertake research and development activities in the state. Also, it has been suggested that the establishment of the two most recent projects, Tonsley Park and Lot Fourteen, have been prompted by the necessity to fill the void of economic activity and have become real property projects rather than economic development projects. The Commission, in noting those views, observes that research, development and innovation are central goals in both cases.

One of the key elements of success of research infrastructure nodes relates to minimising the cost of engagement for tenants, particularly small business. Co-location of companies, as used at the Tonsley Park precinct, minimises the investment required to establish a physical presence.

Participants have stated that the presence of the research institution is the fundamental anchor that attracts companies to an innovation and science precinct. Without the research and commercial anchors, there is very little to differentiate the precincts in terms of what they can offer business.

University stakeholders have indicated that the model of research nodes, when well-established and operated, is an effective model. A clear state government vision to develop and link the various nodes across South Australia is nonetheless required to ensure the infrastructure meets expectations of industry and researchers. The focus of the most recently established research node has detracted from the focus of the node established prior to that, diluting the effectiveness of research infrastructure in the state.

The universities consider that the funding for research infrastructure by the state government needs to be more targeted, particularly with reference to the state's economic priorities and the areas of research infrastructure supported by the Australian Government. In their view, a greater alignment is needed between the state's investment in infrastructure, with the state's science priorities and capabilities in disciplines of research strength.

*Box 5.1: Case Study 1 – Excellence in innovation precincts*

**MicroX**

Established in 2012, Micro-X Limited is a manufacturing company based at the Tonsley Innovation Precinct. The company's first product is a light weight and mobile medical X-Ray cart using carbon nano-tube technology with application in the medical, defence and security markets.

Micro-X listed on the stock exchange in December 2015, to increase access to funding and was originally funded by Australian private investors. The company received a $3 million loan in 2016 from the South Australian Government, which was one of the key sources of motivation to move to the state and to locate at Tonsley. Micro-X has also received funding from the Department of Defence to develop the defence application.

Assembly of the X-Ray cart is done at the Tonsley precinct with the manufacturing process drawing on engineers formerly employed at Holden. Micro-X previously worked closely with Holden to train and transition eight employees to produce their technology.

Co-location at Tonsley enabled Micro-X to develop relationships with postgraduate researchers at Flinders University with the organisations working together to develop knowledge through research in the area.

*Source: https://www.business.gov.au/Grants-and-Programs/Research-and-Development-Tax-Incentive/Customer-Stories/MicroX-Limited*

### 5.1.3 Landmark 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 fifty per cent are located in Australia's universities with the Group of 8 Universities hosting nearly three-quarters of university-based NCRIS facilities.

*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. The Commission was unable to find definitive advice about previous NCRIS facilities in the state. 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 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.

The terms of reference require the inquiry to examine trends in R&D and the factors which influence the extent to which R&D translates into economic growth in SA. The science and innovation precincts relate to factors that influence the extent to which R&D is translated to economic growth. These factors include the benefits of colocation and, more importantly, the capacity of businesses to access and engage with the relevant research excellence in the associated research institutions.

Earlier in chapter 2, the report provided background on three groups: precincts operated by the state; precincts where the state has a presence; and the institutions that the state supports.

This section describes the establishment, capability and operations of the key innovation and science precincts in operation within South Australia. Some of these are operated by the state - Mawson Lakes Technology Park, Tonsley Innovation District, and Lot Fourteen.

The Commission notes that the state has a 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.

### *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 have been established using this type of model. The Adelaide BioMed City precinct is a hub for health and life sciences and is located in the Adelaide CBD; the activities of this precinct are addressed in the Commission's concurrent inquiry into health and medical research.

Mawson Lakes Technology Park

Technology Park at Mawson Lakes was established in 1982 and was originally managed by the Technology Development Corporation as an economic development site for technology-related businesses. As discussed in Chapter 2, the precinct has a varied history of stewardship arrangements, industry focus and objectives.

Renewal SA is responsible for the management of Technology Park on behalf of the state government. The current Salisbury Council Technology Park Development Plan encapsulates the uses of the park. There are informal collaboration arrangements in place between Defence SA, Renewal SA and the University of South Australia in the managing and leasing of tenancies and use of facilities at the park.

There are currently 69 tenants in the two buildings managed by Renewal SA in information technology, defence, design, engineering and technology support with start-up businesses included amongst the tenants.

Thebarton Bioscience Precinct

In 2001, the state government invested in a bioscience industry cluster in Thebarton encompassing the establishment of Bio Innovation SA. This included support to establish five specialist research and manufacturing facilities and five hectares of land under management within a bioscience precinct, shared with the University of Adelaide. The objectives of the precinct were to:

- provide access to capital and finance;
- grow the physical infrastructure available to the industry; and
- provide business development, marketing assistance and effective networks.

A specialist bioscience business incubator was completed in 2008, offering business assistance and research and office space to early stage companies to accelerate their growth. These services were provided by the BioSA Thebarton Bioscience Business Incubator or orchestrated through its network of contacts. It launched its second business incubator, the Tech Hub, in 2014.

It is noted that TechInSA is being wound down, with services for entrepreneurs and start-ups moved to the Office of the Chief Entrepreneur[65]. Tenancies at the Thebarton Bioscience Precinct will be honoured until their contracted end date.

Tonsley Innovation District

The former Mitsubishi site at Tonsley Park has become a precinct of cleantech, sustainable technologies and environmental industries, advanced manufacturing and research and development. The wider Tonsley site is an integrated employment, education and residential precinct.

The state government's current vision of the district is:

[65] 2018-19 Budget Measures Statement, p. 100; Premier of South Australia, 'SA's New Entrepreneurship Model', Media Release (2018).

- the site will add to and engage with the surrounding education and innovation precinct;
- accommodate a significant number of quality jobs;
- provide development based on a transport hub;
- demonstrate best practice urban design and building principles; and
- evolve as a significant institution for southern Adelaide.

It is clear that research and development is one of several objectives for this site.

<u>Lot Fourteen</u>

Lot Fourteen is an innovation incubator and business start-up and growth hub located at the former Royal Adelaide Hospital site on North Terrace. The precinct is in the late stages of renewal and construction with the final assets forecast to be completed by mid-2021. The operation of the precinct will be guided by the following principles:

- sustainable and proactive engagement encouraging collaboration and cooperation with other innovation precincts in the state, rather than competition;
- a focus on the creation of new businesses for SA or assisting existing businesses to grow into new areas within the precinct and ensuring no relocation of businesses from other precincts;
- tenants providing value-added benefit, enabling the precinct to grow;
- applied research with a development horizon of five years or less involving strategic commercial partnerships;
- a product development focus which is technology based with commercial applications; and
- self-sufficiency with paid tenancies to provide a revenue stream.

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. Tenants will be chosen according to a bias towards technology development including capabilities in AI, machine learning, data analytics or cyber security as enablers for growth in other sectors.

Significant assets at the precinct will include an Entrepreneur and Innovation Centre, an Aboriginal Entrepreneurs Hub and an International Centre for Food, Hospitality and Tourism Studies.

The objectives of this precinct are more sharply focused on harnessing research, translation, innovation and commercialisation than Tonsley.

<u>Waite Research Precinct</u>

The Waite Research Precinct co-locates the agricultural research capability of the University of Adelaide with other independent research organisations including CSIRO, the Australian Wine Research Institute (AWRI), the South Australian Research and Development Institute (SARDI) and companies including the Australian Genome Research Facility (AGRF) and Plant & Food Research and Australian Grain Technologies (AGT).

There are strong collaborative links between these organisations and much of the campus infrastructure results from co-investment by these partners. Within the precinct, the Waite Research Institute (WRI) was established in 1924. The WRI supports researchers and teachers who are drawn primarily from the University of Adelaide's agriculturally focused campuses at Waite and Roseworthy, but also include members from all other faculties of the University including health, engineering, professions and arts.

The WRI supports the University in developing and funding strategically important initiatives and by building research capacity and performance. The WRI also supports agricultural research by the University and its partners by providing a 'front of house' service and central coordination point for communications.

<u>Framework for assessment of precincts performance</u>

The Commission's interest in this inquiry is in the context of precincts' R&D and research engagement objectives:

- 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[66], which was developed from an analysis of globally recognised innovation precincts.

The key factors are summarised in Appendix Table A5.1 with elements such as leadership, collaboration and capacity. An additional feature of the framework used by the Commission is when it is appropriate for each factor to be implemented to ensure the most effective outcome. 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 information provided to the Commission and the amount of engagement with stakeholders does not, to date, enable a full determination of the issues. Initial impressions have been hampered by a lack of information (both measurement of performance and interaction of stakeholders, and outcomes at the precincts) and strategic focus of responsible agencies.

The Commission intends to do further work in this area as it develops its final report.

The NSW Innovation and Productivity Council identified the following issues when the growth of precincts is not what was expected or outcomes are less than optimal:[67]

- Precincts may not be economically viable or are unable to generate new economic activity or innovation. These risks are higher when precincts are established with little consideration of the necessary conditions for success.

[66] The Brookings Institution, *Assessing your innovation district: A how-to guide, The Anne T. and Robert M. Bass Initiative on Innovation and Placemaking* (2018).
[67] NSW Innovation and Productivity Council, *NSW Innovation Precincts: Lessons from international experience*, NSW Government Report (September 2018).

- Factors that impede the investment in, and commercialisation of, research and development will slow innovation activity and reduce the success of precincts.
- Restrictive intellectual property controls, a closed academic culture and a tendency for industry to under-invest in research can slow innovation and commercialisation.
- There may be a lack of quality incubator and accelerator programs or other support needed for precinct participants to collaborate.
- Access to capital for firms in start-up and growth phases may be limited.
- There could be local skills shortages which hinder the capacity of the precinct to innovate and scale.
- Insufficient amenity, inadequate public transport and poor tenant infrastructure can reduce the attractiveness of the precinct to employers, workers and start-ups.
- Policies and long-term funding decisions of stakeholders may not support the new technologies, emerging business models and changing demand for skills that are central to successful precincts.

Performance of precincts

The 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 an attempt 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 included the expectation 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 is to be an innovation incubator and business start-up and growth hub located at the former Royal Adelaide Hospital site on North Terrace. 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.

These two precincts differ in focus from the earlier attempts at Mawson Lakes and Thebarton 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 and, as such, making a fair assessment of the precincts needs to recognise this fact. The breadth of aims and objectives imposed on precincts by government may make achieving core aims difficult and this is a theme the Commission will continue to explore. A low number of submissions has been received from stakeholders at the precincts; the Commission will attempt to redress this information gap in publishing the final report.

The Commission notes that the information held in state government on measurement and description of precinct functions and capabilities is quite minimal. The assessment of the success or otherwise of precincts is difficult to undertake in the absence of this information. The Commission sees merit in collecting information that informs performance, priorities and operation at the precincts.

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 widely communicated, understood and have wide-spread buy in;
- do not align well to the region's comparative market advantages at the time the precincts are established;
- have a mode of operation that aims to achieve a multitude of policy objectives rather than a singular economic aim; and
- are not intensive versions of collaborative structures, cultures and behaviours that are economy wide.

A key focus will be to consult both with tenants and precinct stakeholders and with business more broadly on the strategic direction and outputs of the precincts. To date, the interaction between stakeholders and precinct managers has been confined to physical accommodation issues rather than a consideration of priority factors to focus on at different stages of development.

Table 5.3 sets detail on the assessment criteria applied to the active precincts operated by the state (Mawson Lakes, Lot Fourteen, and Tonsley). The assessments are, in effect, an overall assessment of that criterion for those three precincts; they do not relate to any specific precinct. They combine specific information and subjective judgement.

*Table 5.3: Assessment of state-based R&D precincts*

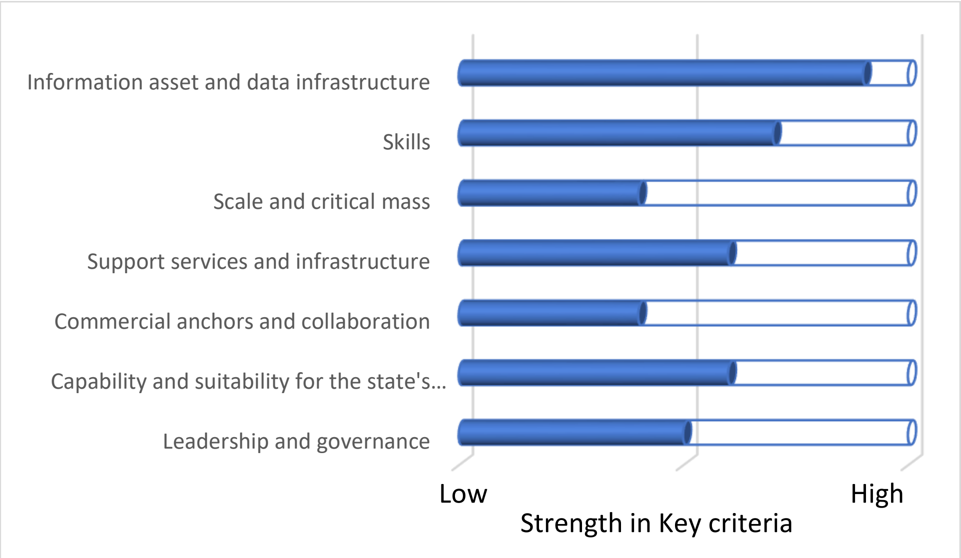
| Key criteria | Key factors | Assessment |
|---|---|---|
| **Leadership and governance** | Establishment of strategic vision and operational model, incorporating stakeholder requirements, and ongoing evaluation and improvement | The evidence provided to the Commission on stakeholder requirements relates 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 appears to be operational rather than strategic 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. However, the depth of engagement, functional responsibility and allocation of resources to specific outcomes does not appear to have |

| Key criteria | Key factors | Assessment |
|---|---|---|
| | | occurred to any 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 | Innovative design programs or processes in precincts have not been demonstrated. |
| | Separation of operation and research focus from other precincts | There appears to be some small overlap in some sectors such as defence, aerospace, information technology and health. |
| **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 only documented for the Thebarton precinct but not the 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 themes focusing activities. |
| | Identification of business types (mature vs start-up) and tenants business capabilities (research strengths, collaboration) | There has been a strong focus on start-ups and their growth in precincts; an area for improvement is the level of support for and transition of start-ups 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. The lack of formal collaboration arrangements may support the view of lack of opportunities and mismatch between sectors. |
| | 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 appears to be 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 do not appear to be strong for business. |
| | Support for local businesses | Tenant businesses are eligible for state-wide schemes and some tenants have accessed these programs in their start-up phase. |
| | Development of formal and informal connections between research institutions | This is an area of weakness with no formal collaboration structures or programs being presented to the Commission. |
| **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, separation of land use, efficient use of land by state governments | The zoning and planning regulations have in the main been patchy with encumbrances providing some limitation to 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. |
| | 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. |

| Key criteria | Key factors | Assessment |
|---|---|---|
| | 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 | This occurred prior to establishment; there is no indication of what decision this information supported and appears to have been done 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 appears to be a great deal of scope for industry to more effectively use the cities' innovation assets. |
| | Level of start-ups 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*

*Figure 5.2: Summary of Commission assessment of innovation precincts*




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

State government perspective on performance of precincts

Renewal SA has emphasised the continuous improvement applied in the operation of innovation and science precincts 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 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 precincts operations and assessment.

Precinct project managers in agencies have sought to avoid 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 the global nature of the vision for the precincts; 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. As such, tenants will be encouraged to work with other disciplines where the opportunity arises.

A key area of attention for project managers is not only the infrastructure aspect but also the accessibility and attractiveness of an area. While drawcards within the precinct attract initial attention 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.

*Box 5.2: State government assessment of the Tonsley Innovation precinct*

**Tonsley Innovation Precinct**

The former Mitsubishi site at Tonsley Park is an integrated, mixed use, employment precinct with education institutions and student accommodation.

Tonsley's Economic Development Plan (EDP) provides strategic oversight of which industry sectors should be targeted and the potential for value-added production. Initial economic development thinking for Tonsley focused solely on 'green tech' industries. However, it was recognised that many other precincts globally shared the same objective and that diversification in industry focus was important. The EDP developed strategy in accordance with South Australia's circumstances and sought to identify what industry sectors had the greatest opportunities for sustainable growth. The sectors chosen were sustainable technologies, clean-tech industries and health and medical manufacturing.

An Investment Attraction and Business Development Plan was developed to identify and recruit key anchor occupants to Tonsley. There was a lot of focus from various stakeholders to target companies aligned with Tonsley's sectors of interest, to support their establishment at Tonsley, with an emphasis on foreign direct investment. This approach has not proven to be fruitful with more success generated through focusing on local business retention and expansion including Flinders University, SAGE Automation, Zeiss and ZEN Energy.

The focus of Tonsley is multi-faceted, focusing on industry development, business development of start-ups, investment attraction, employment, research and development and as a place of accommodation for foreign students. The number of objectives that the precinct has are difficult to achieve concurrently and detracts from the achievement of objectives for a research and development or innovation precinct, particularly objectives of collaboration and commercialising research.

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 formal ties for collaboration and promotion of innovation within the precinct are still be addressed.

Measures of success were compiled in the benchmarking report; these are not tracked or associated with any targets.

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

<u>Performance from stakeholder perspective</u>

The capacity and capability of infrastructure available for most emerging sectors of the economy is seen as ample by the business community 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. For instance, in the biotechnology sector, despite the winding up of the biotechnology precinct at Thebarton, businesses regard the remaining infrastructure in the state, including that contained at the biomedical precinct as sufficient.

Business stakeholders, particularly start-ups, have emphasised the need to focus on industry capability and soft infrastructure, 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.

Businesses have struggled to come to terms with the strategy of precincts offering additional rental space at market rates to uphold market neutrality at times when there was already an oversupply of rental space. Discussions with business start-ups have identified an alternative strategy of focusing on giving a ‘leg-up’ to start-up enterprises and local companies rather than for the government to act as a property developer.

University stakeholders have not provided much by the way of information on their experience with the precincts. Flinders University states that:

> *While no systematic evaluation has been undertaken of the various geographic agglomerations, our view is that considerable mutual benefit has arisen from location of significant elements of our teaching and research activities at Tonsley (Flinders University, DR4,p17)*

### 5.1.5 Conclusions

#### *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 of some benefit. A visible register would promote better engagement between businesses, individuals and organisations across South Australia who are interested in using the infrastructure more effectively. The form of the register would be a matter for the government, and it must have user friendly features with 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 considerable exercise. Further, the delineation between state-government 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.

**Recommendation 5.1: Central information register of R&D infrastructure**

The Commission recommends that the Office for the Chief Scientist, in regular cooperation with universities and industry develop, maintain and promote the extent of research and development infrastructure available for use in South Australia (including national infrastructure networks).

The two most commonly referenced barriers to accessing research infrastructure, identified by stakeholders of all sectors, are firstly awareness of infrastructure assets and their capabilities and secondly funding for infrastructure. The lack of information flows occur throughout the system and affects universities, government and business alike.

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.

Without coordination of effort, infrastructure priorities of the business community can be out of step with the infrastructure acquired. This, combined with a lack of knowledge in the marketplace on the existence of current assets, renders the outcomes of infrastructure use very inefficient.

The Commission considers that the state can improve the way it engages 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. This initial judgement has not been made purely in terms of the quantum of federal money coming to the state. There is a seeming paucity of infrastructure assets outside of the university system supporting key enablers and activities of strategic value in the state.

While acknowledging the work of the Office of the Chief Scientist on future infrastructure priorities, state government efforts do not appear to have borne much to date by way of collaborative arrangements or leveraging Australian Government or industry funding.

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 that will articulate future investment needs and drivers. The Commission can see the value of such a plan and considers that this process will be enhanced by developing priorities in collaboration with end users built to ensure maximum use and benefit of R&D infrastructure inside precincts, universities, state government departments and critical national infrastructure nodes.

The Commission's initial conclusion is that the state government needs to significantly improve its engagement and alignment of priorities with the Australian Government and leverage increased funding for R&D infrastructure assets supporting the needs of business. This will be the source of further investigation and recommendation for the final report.

**Information Request 5.1**

The Commission invites feedback from stakeholders on strategies for the South Australian Government to improve its engagement and alignment of priorities with the Australian Government and to leverage increased funding for R&D infrastructure assets supporting the needs of business.

### *Innovation and Science precincts*

The Commission has found that:

- The standard of infrastructure and facilities of the buildings at the precincts is well regarded and in many cases is of national or global standards.
- 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 appears to have been well organised and executed.
- Clear responsibilities have been allocated for the management of precincts.

In terms of sub-optimal outcomes of the precincts, the Commission concluded that:

- 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 market rental rates.
- There are no formal collaboration arrangements or programs at any of the precincts to promote partnerships and commercial exploitation of knowledge.
- 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 scaling precincts that have been in operation for some time, in terms of growing the interactions within the precincts, improving the amount of services offered to tenants and how to treat businesses once they grow beyond the start-up phase.

- There needs to be improvement in the individual strategies of precincts so that they fit together and have regard to the R&D and innovation landscape in the state.

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 accepts that there is value in proximity but the cost of generating that outcome also matters. If virtual precincts and virtual collaboration are now becoming more culturally acceptable, viable and potentially normal amongst modern knowledge workers, then the cost of virtual vs physical precincts must now be part of the assessment of precincts. The Commission intends to investigate this aspect further.

Based on the Commission's research, the initial conclusion is that physical infrastructure supporting R&D exceeds that which is currently required by business. Publicly provided infrastructure is available and adequate for industry demands, yet it cannot be accessed on a scale to realise its benefits. That may point to an inability to engage with the key research capabilities in the research institutions as well as other factors.

While co-location matters for some businesses more than others this does not diminish the essential requirement for collaboration with researchers and other businesses. If co-location does not occur for some businesses, then collaboration can happen by different mechanisms.

Ultimately these mechanisms become more important for businesses that are unable to co-locate in one of the state's innovation precincts or science parks.

The Commission has observed some 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 likely universal across precincts. Further, the financial models used to construct infrastructure precincts do not appear to actively encourage and support participation by businesses.

Businesses have told the Commission that the offer and existence of services at precincts is a major drawcard but that has not been delivered to businesses when they become tenants. The materialisation of these services is a critical incentive to participation in the precinct for businesses and a necessary counterbalance to the payment of market rental rated for tenants. Without the benefits of tenancy at the precinct, the decision to locate will not pay dividends for business. This is true of other key 'softer' aspects of the infrastructure, including collaboration opportunities.

The Commission has found that the amenities, innovation services and formal collaboration structures offered at precincts are weak in design and practice and in some cases absent from the operations of the precinct. 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.

Industry stakeholders have told the Commission that the standard of infrastructure is very good but the industry base to draw upon it is small. The suitability of businesses being attracted to the hub and being successful depends in part on the level of integration into research activities.

Overall, the Commission's provisional conclusion is the SA experience over the past two decades suggests precincts, as pursued historically and as a policy instrument for research and development, appear to be an inefficient instrument with limited effectiveness in stimulating additional applied research and commercialisation.

The Commission concludes at this point that reform of science and innovation precincts is needed to:

- ensure that there is an offering in essential business capability services and a much sharper focus on industry development at these precincts;
- facilitate better coordination of the strategies and activities of the precincts;
- support increased collaboration activities between tenants at the precincts; and
- to identify targets and collect data that allows measurement of progress toward the objectives of the precinct.

Such reforms will need to consider the dual objectives operating at precincts currently, property management guided by budgetary targets and economic development. There is a sense that the current operations are geared too much towards management of the property rather than long term economic goals.

The identification of reforms and guiding principles of operation for South Australia's precincts will be the subject of further investigation and recommendation in the final report.

**Information Request 5.2**

The Commission invites feedback from stakeholders on the operation for South Australia's innovation and science precincts with regard to:

- ensuring that there is an appropriate offering of business capability services and whether a much sharper focus on industry development is appropriate;
- the scope to facilitate better coordination of the strategies and activities of the precincts; and
- the scope to support increased collaboration activities between universities and businesses at the precincts.

## 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.[68]

[68] 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).

### 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.[69] 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.[70]

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.

One study of applications to the U.S. Department of Energy’s Small Business Innovation Research Program found that the receipt of a grant approximately doubled the probability of that firm receiving subsequent venture capital and had large positive effects on patenting commercialisation.[71] These effects were also found to be stronger for more financially constrained firms.

However, there is also the possibility that government grants can ‘crowd out’ private investment in these opportunities. In cases where government provides support to a company which might otherwise have been able to access finance, not only is there a ‘crowding out’ of private investment, there is also no ‘additionality’ of R&D investment resulting from the grant. Therefore, any grant programs to increase R&D need to be carefully targeted and the extent of additionality assessed.

Investigation of whether the additionality effects of government subsidies outweigh any crowding out effects is difficult as the level of R&D activity that would have been financed without government support is unobserved.

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 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.

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

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[69] 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).
[70] T FCooley and VQuadrini ‘Financial Markets and Firm Dynamics’, (2001) 91 *American Economic Review*,1286-1310.
[71] S Howell, Financing Constraints as Barriers to Innovation: Evidence from R&D Grants to Energy Startups, Working Paper (2015).

Stakeholders also considered that South Australian Government funding 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 to as the valley of death in R&D literature as companies face significant costs in developing a viable product yet must rely existing capital as they are not yet able to generate revenue from this product.

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.[72]

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 fifty per cent investment from other venture capital funds and requires that companies 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 requirement and instead targets companies with export and high growth potential that have a demonstrated market for their product or service.[73]

The Commission has heard from 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 Commission was provided evidence by the SAVCF 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 been a function of the BlueSky business model (the previous fund manager), in which the nature of the mandate was to generate income for the government and required businesses to prove the business can generate commercial returns. This mandate has since been reviewed. Of 46 opportunities assessed in 2020 to date, five have come from (or been developed in) a university with all five being in healthcare or medical devices.

[72] ABS 5678.0 – Venture Capital and Later Stage Private Equity, Australia.
[73] https://www.savcfund.com/

### 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 a combination of:

- 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 has 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 expressed a desire for state government support in attracting senior internationally renowned researchers, arguing that 'South Australia is often at a disadvantage in retaining and attracting new and innovative 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'[74].

*Box 5.3: Case Study 2 – Government support for university appointments*

**Value of investment in a Research Chair**

Just before 2010 Flinders had an extremely limited forensic Deoxyribonucleic acid (DNA) program; forensic biology was then and still is one of the most important fields in modern forensic science. Flinders was able to obtain funds from the South Australian Government to provide the salary for a Chair specialising in forensic DNA teaching and research. This attracted a world-leading appointee from the UK who in the past decade

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

has created the best, most productive research and teaching programs in Australia and amongst the best worldwide. Currently there are seven forensic DNA PhD students evidencing that attracting high talent is not a barrier when the right levers are in place. Since 2010, over 110 papers have been published in international peer-reviewed journals. Of the previous nine postgraduate alumni, two have developed collaborations with partners in the USA and three with groups in SE Asia.

*Source: Flinders University DR4, p.12*

The Commission has also heard concerns, especially from smaller universities, that assessors sometimes make judgements based on their perception of the standing of a 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)*

The University of Adelaide expressed concerns 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)*

<u>Funding for indirect costs</u>

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 is a result of their performance in attracting other funding and PhD students.

The block grants are calculated based on the amount of other funding the universities have earned. The allocation process does not recognise that the indirect costs of a research project vary substantially given the nature of a project. This includes both across and within fields of research. As a result, the block grants can be seen as 'a mixture of subsidy and bounty' depending on the degree to which a project is funded.[75]

Universities have expressed a concern that 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)*

[75] R Williams, "Evaluating the Contribution of Higher Education to Australia's Research Performance', (2016) 49(2) *The Australian Economic Review*, 174-83.

General University Funding

In South Australian universities, 44.9 per cent of R&D is funded by general university funds. The largest source of this comes from surplus revenue from teaching. This includes both domestic students, where it has been estimated that the cost of teaching was only 85 per cent of the Commonwealth supported place[76], and international students, from whom revenue far exceeds the Commonwealth supported place. One recent estimate suggests that nationally 27 per cent of university research is funded by international student fees.[77]

The reliance on this source of revenue, especially from international students, has serious implications for South Australia's R&D expenditure going forward. 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 between now and 2023.[78]

University R&D expenditure is particularly vulnerable to this loss of revenue, with Universities Australia estimating that between $3.3 billion and $3.5 billion of university R&D activity annually could be at risk.[79]

Any significant loss of university revenue from student income would be likely to have a detrimental impact on the amount of other research funding a university can receive from sources that require a co-investment, such as the Medical Research Future Fund; or reduce a university's ability to invest in collaborating with industry, including through investing in CRCs. In addition, any significant reduction in 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 this research.

### 5.2.4 Conclusions

South Australia's universities have become increasingly 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. The reliance on international student fees to fund research has serious implications in the short-term for university R&D.

South Australian universities also have a lower success rate in applying for competitive grants through the ARC than the national average. Stakeholders have 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.

## 5.3 Access to data

For many fields of research, data is a critical resource. The availability and accuracy of data can be a limiting factor for R&D across all sectors. Governments play a part in setting access rules and specifically access to the data they collect for their own purposes.

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[76] Deloitte Access Economics, *Cost of Delivery of Higher Education* (2016), Final Report, p. xxii
[77] 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/>
[78] 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/>
[79] Ibid.

### 5.3.1 Government data

The large volume of data held by the Australian Government and its state and territory counterparts has come to be seen as an underutilised and valuable national resource.[80] Sophisticated use of data for public policy can assist in innovating and improving the flexibility and responsiveness of public services. Similarly, there may be opportunities for commercial businesses to produce innovative services and products using such information.

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, making adherence mandatory for 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, 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'[81].

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 sought to enhance 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.[82]

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.[83]

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[80] 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>

[81] Department of the Premier and Cabinet (SA), PC 012 – Information Privacy Principles Instruction (2017), 3.

[82] 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>*.

[83] DPC, Open Data, (2020), <https://www.dpc.sa.gov.au/responsibilities/data-sharing/open-data>

From discussions with Government agencies, the Commission understands that 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, unit record level of data may not be published or shared with researchers and a level of aggregation is required to maintain privacy and not release any material that might be commercial in confidence. 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.

In some circumstances, it might be appropriate for government to consider options to increase access to these unit records. Section 13 of the *Public Sector (Data Sharing) Act 2016* enables government to 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. That said, as there is no central point of contact in government for these requests, the Commission heard that it is unclear in many cases who researchers should contact. This decentralised structure also means that it is 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 by individual decision makers. The outcome of a request can differ depending on the initial point of contact.

Improvements to this process for proactive publication of, or improved access to, data is one aspect within the State’s control that could have strong benefits to South Australia’s R&D sector.

There are also options available to improve use of unit record level data while still meeting privacy requirements. One possible model is that used by the Australian Bureau of Statistics for sensitive data such as the Business Longitudinal Analysis Data Environment (BLADE). Under this model, research topics are approved by the ABS in advance and researchers use ABS facilities or virtual data labs to access the database and no data can be exported or released publicly without ABS approval to ensure privacy requirements as well as other legislative requirements are upheld.

The Commission notes that any additional involvement in organising and publishing data for researchers outside of government is likely to impose additional costs. As a result, it may be appropriate for government to investigate options to charge for access to some of this data.

***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 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.[84] 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.

### 5.3.2 Other data

In addition to government, businesses and universities collect large amounts of data for both R&D and other purposes.

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 to 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 has heard that the costs of purchasing data can be high, with one company which was formed out of a CRC having annual data costs exceeding $400,000. These costs are likely to be unaffordable for most small businesses and start-ups.

Stakeholders raised 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 businesses 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'[85]. The Rozetta Institute purchases data and offers subscription data packages to its member organisations.

Other than noting the potentially high cost of data, stakeholders have not raised significant issues with access to non-government data for non-health and medical R&D.

[84] < https://www.dpc.sa.gov.au/responsibilities/economic-insight-and-evaluation>
[85] <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; and
- talent pools and the capacity to attract new talent into research.

## 6.1 Talent, skills and demography

### 6.1.1 Introduction

The economic literature does not establish explicit links between skills and innovation; however, the ability to undertake research and development is an exercise that requires, on average, a necessary level of education and training.

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.[86]

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, the overall stock of knowledge generated from all sources has a significant influence. A 2006 Australian Productivity Commission staff paper found the effects of R&D performed overseas were positive and economically significant. Both foreign knowledge stock and patent measures are shown to have a large impact on the level of business R&D and on Australia's productivity[87].

The South Australian Chief Scientist advised the Commission that while ranked 15th out of 30 OECD countries for the total number of R&D personnel per 1,000 people employed, Australia was ranked 8th in its contribution to the top 1 per cent of highly cited research publications per million population. Australia has relatively high rates of graduation from Higher Degrees by Research (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).

*Box 6.1: Case Study 3 – Excellence in R&D workforce development*

**Redarc Electronics**

Redarc was founded in the late 1970s developing voltage converters adapted to foreign trucks used in Australia. The company factory is based at Lonsdale.

The focus of the company changed in the early 2000s with the company hiring its first engineer in 2002 and investing 15 per cent of every dollar earned into R&D. The first product developed was a dual-battery isolator, for using an auxiliary power battery in a car or truck. The appeal of this product has been international, with applications to

[86] 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).
[87] Sid Shanks and Simon Zhang, *Econometric Modelling of R&D and Australia's Productivity, Australian Productivity Commission*, Staff Research Paper (2006).

caravan and campervans and accordingly the export base has grown significantly over the last five financial years to become a much larger proportion of total company sales.

Redarc currently has a team of 40 engineers out of 200 staff who are a key component of the business and future outlook, where innovation is a key driver.

The company has focused on IP and invested in R&D over the last five years filing for a number of patents or having applications pending. PhD students have been embedded into the business and PhD students hired by the company have been embedded into the university. Redarc has R&D relationships with all three public universities and with defence companies.

Redarc provides its engineers with a 3-5-year technology horizon to embed technology in their products and solve teething problems and to trial applications without the pressures of a commercial venture. The company considers this approach has proven advantageous and differentiates R&D from the usual product development process.

*Source: SAPC and https://www.caradvice.com.au/841047/great-australian-companies-redarc-electronics/*

### 6.1.2 Stakeholder feedback

Business stakeholders have observed that South Australia has in most cases an adequate level of talent. Their experience has been more positive in recruiting and developing high-quality local graduates than attracting experienced local or external workers.

Conversely, rural research stakeholders have identified current shortages of agriculture graduates and postgraduates. The Waite Research Institute confirmed that generating interest amongst domestic students in taking up agriculture as a career remains a challenge.

Public universities have reflected that due to the highly competitive nature of world-class research, South Australia is often at a disadvantage in retaining and attracting new and innovative researchers through 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. This is in the context of some examples of specialised, world class research areas such as at the Australian Institute of Machine Learning.

Public universities have told the Commission that the perception of limited employment opportunities, especially outside academia 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; accordingly, 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; 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.

The University of Adelaide pointed to national surveys indicating that more than half of PhD graduates in Australia find employment outside of academia. Commercial and government organisations recognise that PhD graduates bring highly-developed critical thinking, as well as analytical, discovery and communications skills that can be transformative for their organisations. However, some employers shun postgraduates, regarding deep specialist knowledge as a limitation rather than of potential value to help grow the business.

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.

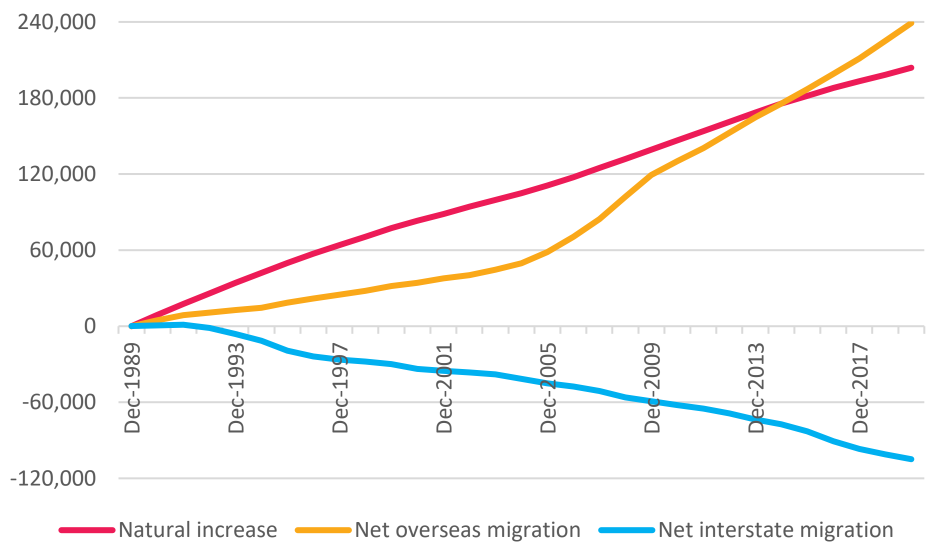
### 6.1.3 South Australia’s demographic trends

The R&D performance of South Australia’s labour force needs to be considered in the context of the state’s demographics. The number of people and their age are the predominant demographic influences on the supply of workers and their productivity.

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 fertility rates and net interstate migration outflows. Fertility rates in South Australia have on average been slightly less than or equal to Australia (approximately 1.8). See Appendix 6 for a graphical illustration of state and national rates.

Net interstate migration outflows have been a constant trend in South Australia’s 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.

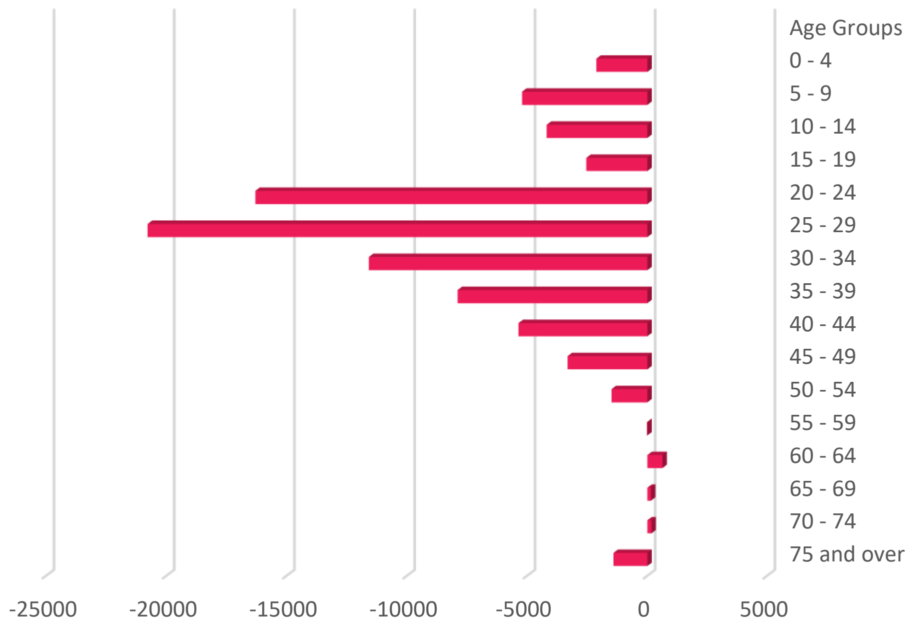
*Figure 6.1: Components of South Australia’s population change, cumulative total, 1989-2019*




*Source: ABS Catalogue No. 3101.0 Australian Demographic Statistics, December 2019*

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. South Australia has therefore become increasingly reliant on overseas migration for workforce supply, supplemented by a working age cohort of 65 years and over that is larger than that of the rest of Australia.

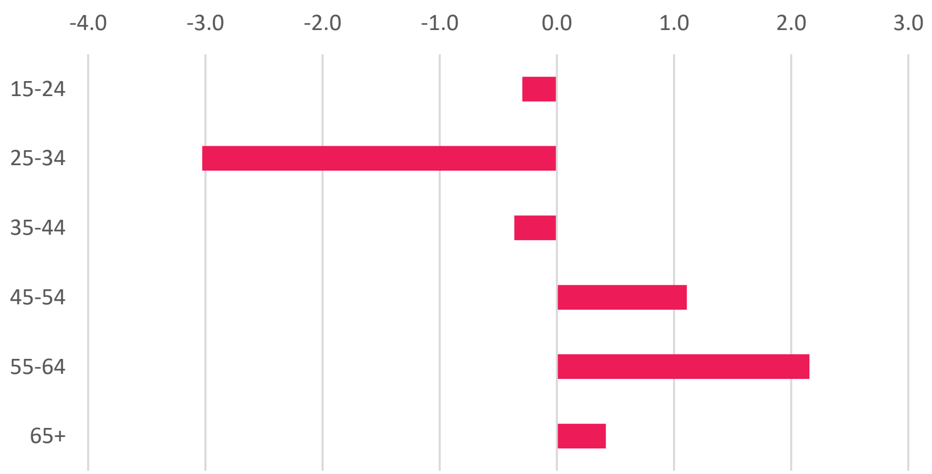
*Figure 6.2: Cumulative net interstate migration outflows for South Australia by age group, 1997-2019*




*Source: ABS Catalogue No. 3101.0 Australian Demographic Statistics, December 2019*

Net outflows of population interstate have a heavy skew towards professional occupations which includes many STEMM-related and research positions from business, government and research institutions. Further, as shown in the previous section, graduates often move states prior to commencing their first full-time position post-graduation. The cumulative outcome of so many professional workers departing the state, in net terms, over such a long period of time has significant effects on age structure, productivity of the workforce and 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, some 19,500 people in the 22-year period of available data.

*Figure 6.3: Percentage point difference in the size of working age cohorts in South Australia in reference to the rest of Australia*




*Source: ABS Catalogue No. 3101.0 Australian Demographic Statistics, December 2019*

Having a smaller percentage of the population in this age group, other things being constant, means reduced entrepreneurship going forward, 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 (as older individuals remaining in the workforce will reduce the opportunity for younger workers to gain skills and capabilities through occupational advancement)[88].

Data on business formation and exit from June 2019 suggest that South Australia has a relatively static business sector. South Australia's share of new business entries is well below its population share (6.9 per cent) 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.[89]

### 6.1.4 Educational Attainment

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 |
| Aus | 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 inference may be that the SA economy does not generate enough of the right jobs to employ the supply of graduates. A common theme throughout this report is lack of scale in the SA economy to use its resources and generate growth.

[88] 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).
[89] 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 |

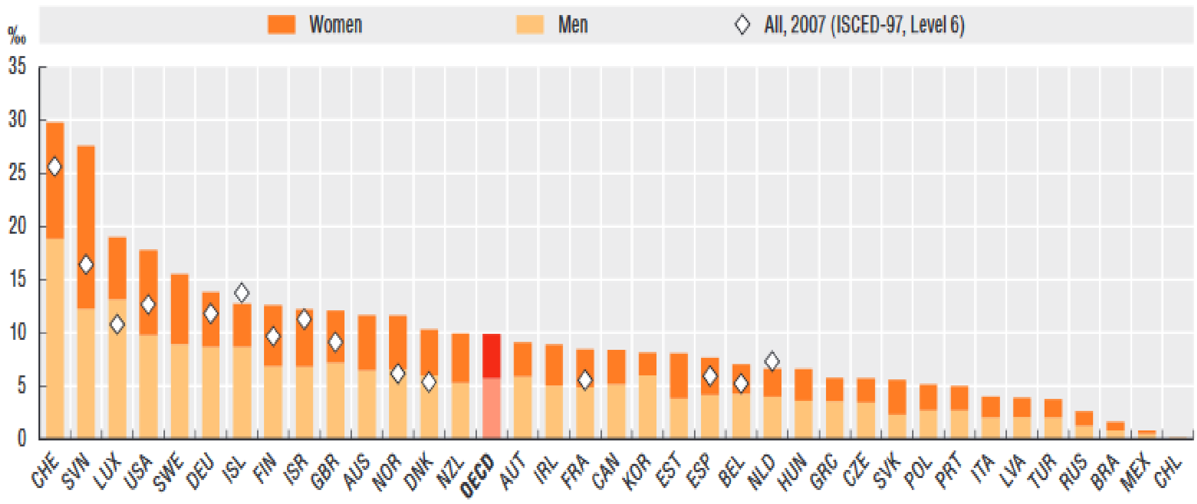
*Source: ABS Catalogue No. 6291.0.55.003, Labour Force, Australia, Detailed, Quarterly, February 2020, Table 24a*

### 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 a lack of 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 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 6.4: Doctorate holders per thousand population aged 25-64, by country, 2016*




*Source: OECD[90]*

In 2016, Australia had a slightly higher proportion of PhD holders in the working age population than the OECD average, shown in Figure 6.4.

[90] OECD, *OECD Science, Technology and Industry Scoreboard 2017: The Digital Transformation* (OECD Publishing Paris, 2017).

Another option is to rely on national surveys of businesses and governments to report their number of staff devoted to research. However, the Commission is not aware of any such survey with sufficient observations to make reliable inferences about the difference between South Australia and other states.

OECD data suggests that approximately 46 per cent of researchers in Australia were employed in the higher education sector in 2016.[91] 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.

An analysis of LinkedIn data in 2019[92] found that 52 per cent of PhD holders in Australia were employed in the higher education sector, with a further 23 per cent employed in the business sector and 24 per cent employed in government and non-government organisations.

### *Higher Education*

South Australian universities devoted 5,301 person years of effort[93] (PYE) to R&D in 2018, as shown in Table 6.3.

*Table 6.3: Higher education human resources devoted to R&D, PYE, by location, by type, 2018*

| Type of staff | NSW | Vic. | Qld | SA | WA | Tas. | NT | ACT | Aust. |
|---|---|---|---|---|---|---|---|---|---|
| Academic staff | 7,285 | 7,241 | 4,365 | 1,848 | 1,920 | 797 | 137 | 1,199 | 24,794 |
| Other staff | 3,710 | 2,528 | 2,652 | 492 | 850 | 189 | 59 | 797 | 11,276 |
| Postgraduate students | 14,500 | 12,168 | 7,991 | 2,960 | 4,081 | 1,064 | 245 | 2,639 | 45,647 |
| **Total** | **25,495** | **21,936** | **15,008** | **5,301** | **6,852** | **2,050** | **441** | **4,635** | **81,717** |

*Source: ABS 8111.0*

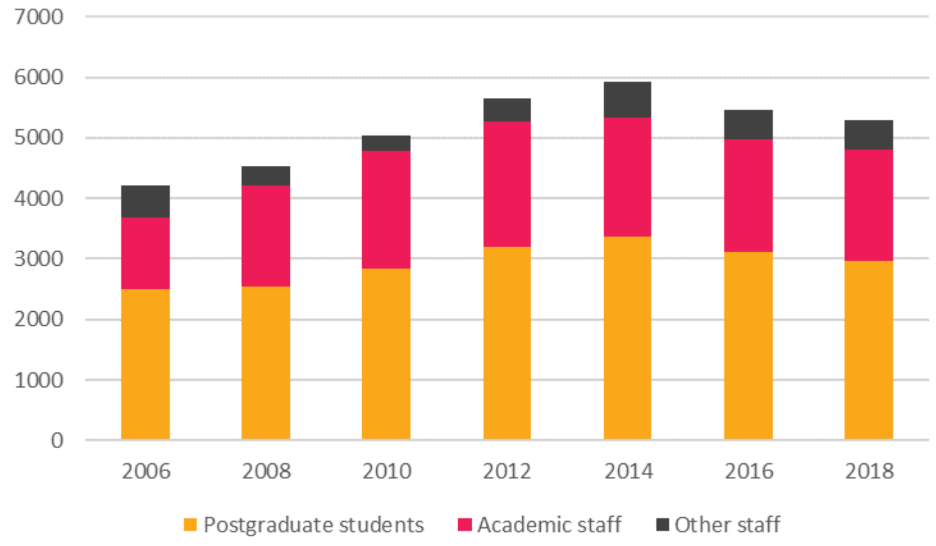
South Australian universities were host to 6.5 per cent of Australia's higher education total staff PYE devoted to R&D. This includes 7.5 per cent of academic staff, 4.4 per cent of other staff and 6.5 per cent of postgraduate students.

[91] 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.

[92] P McCarthy and M Wienk, *Advancing Australia's Knowledge Economy: Who are the top PhD employers?* (AMSI, 2019), 4. <https://amsi.org.au/wp-content/uploads/2019/04/advancing_australias_knowledge_economy.pdf>

[93] Most researchers in the higher education sector undertake research as only part of their responsibilities, with them also required to undertake teaching and administrative work not related to their research. Therefore, the ABS estimates research time in person years of effort, a full-time equivalent measure of research time.

*Figure 6.5: Higher education human resources devoted to R&D, PYE, by type, South Australia*




*Source: ABS 8111.0*

Over the 10 years to 2018, the total number of PYE devoted to R&D has risen by an average of 1.6 per cent per year. This growth is largely a result of increases in postgraduate students and other staff with the number of academic staff (PYE) in 2018 only 9.5 per cent higher than 2008 and all categories have decreased since 2014.

At the institution level, it is difficult to estimate the research workforce as the majority of staff have research, teaching and other responsibilities.

*Table 6.4: Higher education staff, full-time equivalent (FTE), by institution, by function, 2018*

| State/Institution | Teaching only | Research only | Teaching and research | Other | Total FTE |
|---|---|---|---|---|---|
| Flinders University | 66 | 242 | 610 | 1,038 | 1,956 |
| The University of Adelaide | 97 | 611 | 741 | 1,952 | 3,400 |
| Torrens University Australia | 71 | 8 | 8 | 17 | 104 |
| University of South Australia | 195 | 423 | 515 | 1,508 | 2,642 |
| South Australia – Total | 429 | 1,284 | 1,874 | 4,515 | 8,102 |
| Australia – Total | 4,655 | 15,353 | 27,010 | 62,005 | 109,021 |
| SA share of national | 9.2% | 8.4% | 6.9% | 7.3% | 7.4% |

*Source: Department of Education, Skills and Employment, 2018 Staff full-time equivalence*

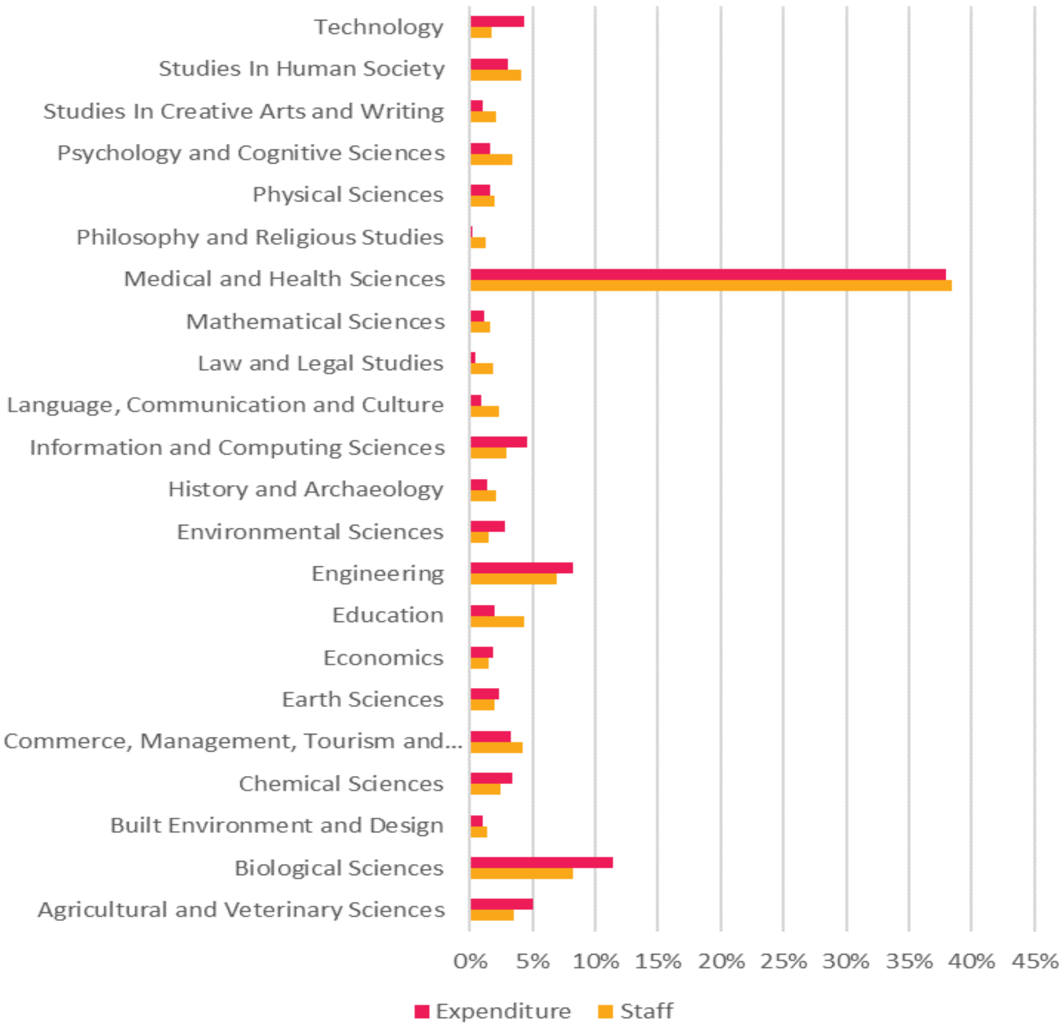
South Australian universities have a slightly higher proportion of teaching only staff (5.3 per cent compared to 4.3 per cent nationally) and research only staff (15.8 per cent compared to 14.1 per cent nationally).

The only data that the Commission has identified for the number of researchers in each field of research for each state is the ARC's Excellence in Research for Australia (ERA) Research Workforce Data. However, the Research Workforce Data used by the Commission is based on a headcount submitted by universities for the ERA. The staff included must meet the ERA definition of a member of staff and must have an affiliation with an institution on the census date[94]. As a result, the data makes no adjustments for staff employed on a fractional or casual basis or seconded and unpaid visiting staff. When compared to the ABS estimates, the ERA data also does not include postgraduate students unless they are also employed by the institution in a research role.

The ERA workforce data show that of the 6,520 research staff employed in South Australian universities, 38.5 per cent worked in the medical and health sciences field in 2018. This is a 43.8 per cent increase in the number of medical and health sciences researchers since 2010.

Between 2010 and 2018, there has been a 30.6 per cent increase in the number of research staff employed in South Australia, while the number of person years of effort in research (excluding postgraduate students) has risen by only 0.4 per cent. This implies there has been an increase in the number of casuals and part-time staff over this period.

*Figure 6.6: Higher education R&D, share of total expenditure and staff by field of research, South Australia, 2018*




*Source: ARC ERA Workforce Data and ABS 8111.0*

94 Eligibility criteria for researchers is defined in section 4.3.1.1 of the ERA submission guidelines available at https://www.arc.gov.au/excellence-research-australia/key-documents

Since 2010, research staff numbers have fallen in language, communication and culture (26.3 per cent), built environment and design (4.0 per cent) and education (3.8 per cent).

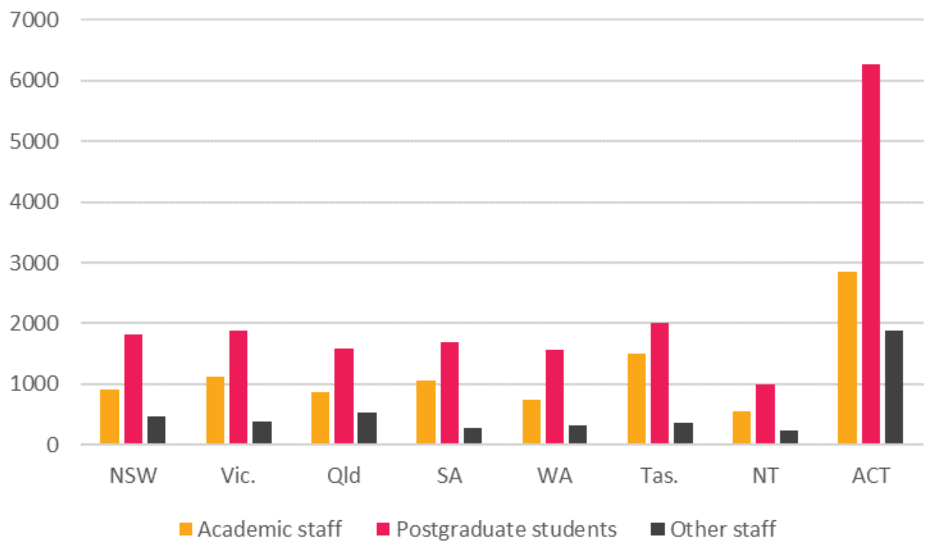
The fastest growing fields of research by staff numbers have been agricultural and veterinary sciences (80 per cent), information and computing sciences (60.8 per cent), engineering (55.2 per cent) and medical and health sciences (43.8 per cent).

There is a high correlation between the number of researchers employed in each field of research with the expenditure on R&D. As the staff numbers are a headcount rather than an FTE or PYE measure, any differences could reflect either differences in the cost of research across fields or differences in the proportion of part-time or casual researchers.

### *Measures of R&D intensity*

In the context of the R&D workforce, measures of intensity could include number of researchers per 1 million population, or per working age population.

*Figure 6.7: 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, 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

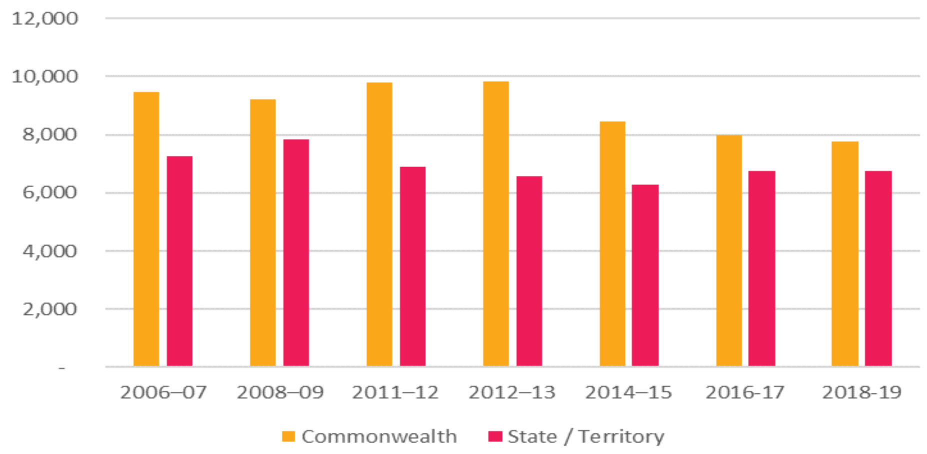
Across Australia, OECD data suggests that 8.6 per cent of researchers were employed in the government sector in 2016.[95]

The ABS publish 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. In 2018-19, there were 7,763 Australian

[95] OECD.Stat, (2020), R&D personnel by sector and function, 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.

Government employees (PYE) and 6,758 state and territory government employees (PYE) devoted to R&D across Australia.

*Figure 6.8: Government human resources devoted to R&D, PYE, Australia*




*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. Under the assumption that the expenditure on R&D per employee is the same across all states and territories in Australia for all levels of government, this would imply that there are approximately 1,250 Commonwealth and 635 state government researchers (PYE) in South Australia.

An alternative approach might be to assume that the proportion of researchers per sector is consistent across Australia. The higher education sector is the only sector for which consistent state level data is available. Using the ABS estimates of higher education human resources dedicated to R&D and OECD data that suggests 45.8 per cent of researchers work in the higher education sector and 8.6 per cent in government, this implies that approximately 1020 employees (FTE) work in the government sector in South Australia. However, as discussed in section 3.2, South Australia has a greater share of national Government R&D expenditure than other sectors, so the Government research workforce in South Australia is likely to be greater than this estimate.

The Commission has not identified any data on the size of the research workforce within various operations 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.[96]

### 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.[97]

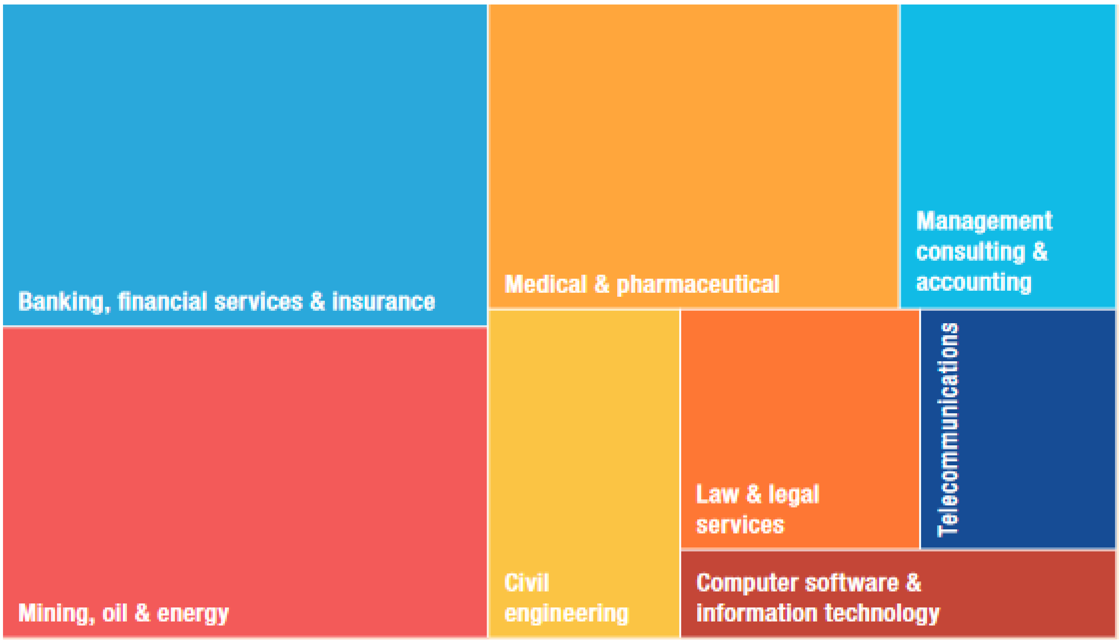
[96] P McCarthy and M Wienk, *Advancing Australia's Knowledge Economy: Who are the top PhD employers?* (AMSI, 2019) 9, <https://amsi.org.au/wp-content/uploads/2019/04/advancing_australias_knowledge_economy.pdf>

[97] 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.

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. If these proportions held, and SA had an equivalent share of private sector research staff, the number of staff in the private sector and in higher education would be similar. However as discussed in section 3.2, 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.[98] 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.

*Figure 6.9: The main industries employing PhD graduates in Australia*




*Source: P McCarthy and M Wienk, Advancing Australia's Knowledge Economy: Who are the top PhD employers? (AMSI, 2019)*

### 6.1.6 Research workforce findings

The 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 through:

- quantifying the state's STEMM workforce and comparing this workforce to that of the rest of Australia;
- analysing skill levels of the STEMM workforce compared to that of the rest of Australia;
- analysing the higher education workforce; and

[98] P McCarthy and M Wienk, *Advancing Australia's Knowledge Economy: Who are the top PhD employers?* (AMSI, 2019) 9,

- discussing the supply of labour through higher education institutions and graduate employment outcomes.

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 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 researchers, technicians and other support staff (such as administrators, clerical workers and craftspeople).[99]

***The STEMM workforce***

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.

Ideally, quantifying the uptake and use of STEMM skills in the economy would be the preferred method to support policy analysis of the extent of innovation and research skills in the economy and their effect[100]. However, there is little public data available on the use of STEMM skills or even in quantifying STEMM output. A 2014 ABS publication is one of the few sources of information examining science, technology, engineering and mathematics qualifications and occupations of the Australian workforce.[101]

Using an occupation list published on the Australian Government Labour Market Information Portal[102], the Commission has quantified the extent of the STEMM workforce in South Australia compared to the rest of Australia.

Table 6.5 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 has a higher representation in the total STEMM workforce of medical occupations (38.6 per cent compared to 30.9 per cent) and a lower representation in IT occupations (12.9 per cent compared to 17.8 per cent).

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[99] 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

[100] B Freeman, *Securing Australia's Future – STEM: Country comparisons –snapshots of 23 Science, Technology, Engineering and Mathematics (STEM) consultants' reports: Characteristics, lessons, policies and programs,* Australian Council of Learned Academies, Consultant Report (2013).

[101] Australian Bureau of Statistics, *Perspectives on Education and Training: Australians with qualifications in science, technology, engineering and mathematics (STEM)*, *2010–11*, cat. no. 4250.0.55.005 (2014).

[102] Labour Market Portal <https://lmip.gov.au/default.aspx?LMIP/GainInsights/SpecialTopicReports> Accessed 16/06/2020

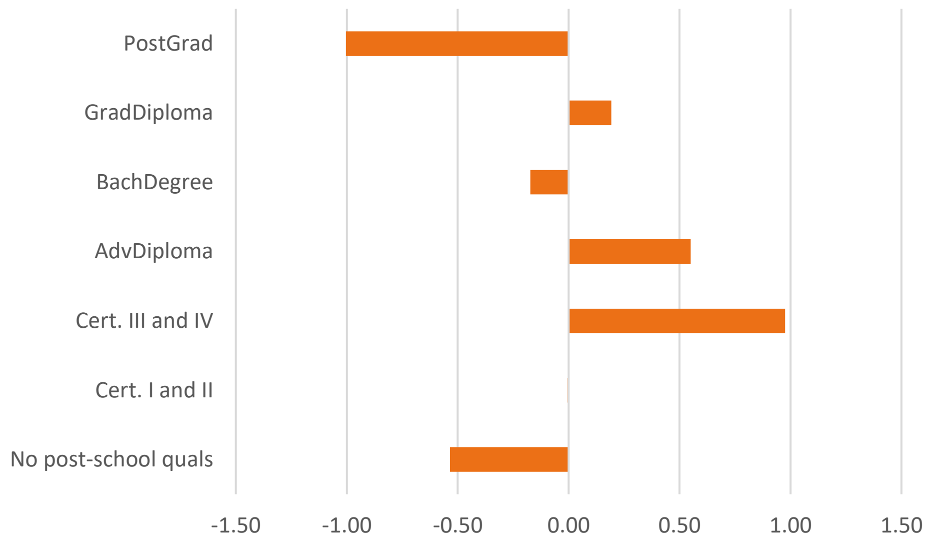
*Table 6.5: STEMM workforce by category of occupation, SA and the rest of Australia, 2018.*

| Category | SA | % | Rest of Australia | % |
|---|---|---|---|---|
| Science, agriculture and environment | 8,752.5 | 5.7 | 122,066.8 | 5.2 |
| Maths | 20,369.0 | 13.2 | 381,364.1 | 16.3 |
| IT | 19,931.6 | 12.9 | 416,691.1 | 17.8 |
| Engineering | 45,699.3 | 29.6 | 697,548.1 | 29.8 |
| Medical | 59,630.0 | 38.6 | 721,914.6 | 30.9 |
| Total | 154,382.3 | 100.0 | 2,339,584.7 | 100.0 |

*Source: SAPC calculations based on Training and Skills Commission of SA data*

In terms of the skill profile of the state's STEMM workforce, 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.

*Figure 6.10: 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*

***Field of research profile of the higher education sector workforce***

This section explores in more detail the R&D workforce in comparison to the rest of Australia. In line with the STEMM workforce, South Australia has proportionally more of the workforce employed in medical and health science research activities than the rest of Australia (38.4 per cent compared to 29.9 per cent in 2018). The proportion of labour resources employed towards medical and health sciences has increased since 2010. South Australia has proportionately less labour devoted to engineering, commerce and education research than the rest of Australia.

*Table 6.6: Higher education institution Workforce, SA and the rest of Australia, by field of research 2010-2018, proportion of total headcount (%)*

| | 2010 | | 2012 | | 2015 | | 2018 | |
|---|---|---|---|---|---|---|---|---|
| | SA | Rest of Australia | SA | Rest of Australia | SA | Rest of Australia | SA | Rest of Australia |
| Mathematical Sciences | 1.9 | 2.1 | 2.0 | 2.0 | 1.8 | 1.9 | 1.6 | 1.9 |
| Physical Sciences | 1.8 | 2.4 | 1.7 | 2.5 | 1.9 | 2.5 | 2.0 | 2.4 |
| Chemical Sciences | 2.4 | 2.8 | 2.2 | 2.9 | 2.3 | 2.9 | 2.5 | 2.7 |
| Earth Sciences | 2.2 | 2.0 | 1.9 | 2.0 | 2.2 | 2.2 | 2.0 | 2.3 |
| Environmental Sciences | 1.4 | 1.7 | 1.9 | 1.8 | 2.2 | 2.0 | 1.5 | 2.2 |
| Biological Sciences | 7.6 | 8.2 | 8.3 | 7.9 | 8.8 | 7.4 | 8.2 | 7.6 |
| Agricultural and Veterinary Sciences | 2.6 | 2.5 | 3.3 | 2.7 | 3.3 | 2.9 | 3.6 | 2.6 |
| Information and Computing Sciences | 2.4 | 4.6 | 1.9 | 4.1 | 2.4 | 4.0 | 2.9 | 3.7 |
| Engineering | 5.8 | 6.9 | 6.7 | 7.0 | 7.5 | 8.3 | 6.9 | 8.6 |
| Technology | 2.2 | 1.1 | 2.2 | 1.2 | 1.9 | 1.3 | 1.8 | 1.0 |
| Medical and Health Sciences | 34.8 | 25.4 | 34.6 | 26.2 | 35.5 | 27.0 | 38.4 | 29.9 |
| Built Environment and Design | 1.8 | 2.1 | 1.8 | 2.1 | 1.8 | 2.2 | 1.4 | 2.1 |
| Education | 5.9 | 6.5 | 5.7 | 6.3 | 5.3 | 5.8 | 4.3 | 5.7 |
| Economics | 1.7 | 2.2 | 1.6 | 2.1 | 1.4 | 1.8 | 1.5 | 1.7 |
| Commerce, Management, Tourism and Services | 5.5 | 6.7 | 5.2 | 6.4 | 4.5 | 5.9 | 4.3 | 5.3 |
| Studies in Human Society | 4.9 | 5.2 | 4.9 | 5.4 | 4.5 | 5.3 | 4.1 | 5.0 |
| Psychology and Cognitive Sciences | 3.2 | 3.5 | 2.9 | 3.5 | 3.0 | 3.3 | 3.4 | 3.6 |
| Law and Legal Studies | 2.0 | 3.0 | 2.2 | 2.9 | 1.9 | 2.7 | 1.8 | 2.5 |
| Studies in Creative Arts and Writing | 2.5 | 3.9 | 2.6 | 3.6 | 2.6 | 3.4 | 2.1 | 2.9 |
| Language, Communication and Culture | 4.1 | 3.8 | 3.5 | 3.6 | 2.9 | 3.5 | 2.3 | 3.0 |
| History and Archaeology | 2.0 | 2.0 | 1.8 | 2.1 | 1.5 | 2.1 | 2.1 | 1.9 |
| Philosophy and Religious Studies | 1.2 | 1.6 | 1.2 | 1.6 | 1.0 | 1.6 | 1.2 | 1.5 |
| **Total** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** | **100.0** |

*Source: Data provided to SAPC on request from the ARC. Research workforce data is based on headcount as submitted for the ERA 2010, 2012, 2015 and 2018 rounds. Staffing data submitted by universities for ERA evaluations must meet the definition of a 'member of staff' and the staff member must have an affiliation with an institution on the staff census date. Headcount represents the raw number of employees and includes staff employed on a full-time or fractional full-time basis, on a casual basis as well as 'other employed'. Staffing data submitted for ERA is linked to individual universities, but not based on the locations of their work or state. State-based data is therefore an aggregation of individual university data for each state and territory.*

### *Research workforce sources of supply*

Postgraduate students are a large component of the R&D labour force, contributing 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 university sector in South Australia to increase the share of R&D funding. Further, a pipeline of postgraduate students sustains R&D activities inside universities.

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 are 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 6.7: 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 |
| FlinArchitecture 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*

While the workforce destination of South Australian graduates is unknown, information contained within the survey of Australian graduates provided to the Commission gives an indication of workforce participation and employment rates for South Australian graduates who participated in the survey. This information includes undergraduates as well as postgraduates and includes higher education qualifications offered through Technical and Further Education South Australia (TAFE SA).

*Table 6.8: Participation rate of all graduates by location of institution by year, 2013-19, SA and the rest of Australia (%)*

| | 2013 | 2015 | 2017 | 2019 |
|---|---|---|---|---|
| SA | 85.2 | 82.5 | 91.6 | 91.9 |
| Rest of Australia | 86.7 | 87.8 | 91.9 | 91.9 |

*Source: 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).*

Participation rates of graduates with higher education qualifications from South Australian institutions are comparable with the rest of Australia and have increased steadily over the past six years (as measured by those graduates taking part in the survey). Employment rates have shown a slight decline for graduates in both South Australia and the rest of Australia over the last six years suggesting a recent tightening of the labour market.

*Table 6.9: Employment rate of all graduates by location of institution by year, 2013-19, SA and the rest of Australia (%)*

| | 2013 | 2015 | 2017 | 2019 |
|---|---|---|---|---|
| SA | 85.5 | 86.3 | 84.5 | 84.7 |
| Rest of Australia | 86.1 | 86.0 | 84.9 | 84.0 |

*Source: 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).*

The results indicate that South Australian graduates are participating in the labour force to the same extent as graduates in the rest of the country, with prospects of being employed at similar levels.

Information on matching of skills and levels of underemployment, career opportunities and future occupation cannot be inferred from the graduate outcome survey statistics. Clearly, these factors weigh heavily on those graduates who choose to move away from South Australia.

Stakeholder interviews emphasised the importance of young researchers developing local knowledge through their studies and in extension of their research. Having locally trained researchers and education providers will ensure enduring benefits for all sectors. The reduction of government funded R & D has reduced the number of employment opportunities for graduates and hence reduced enrolments. Stakeholders consider it is fundamentally important to reinstate this capacity through scholarships, bursaries and co-funded positions with industry, and direct funding of key positions.

The Crop Sciences Society of South Australia argued that an increase in investment specifically to facilitate regional research and education is critical to maintain local research capacity to maximize local growth opportunities.

***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 factor interrupting the potential supply of postgraduate researchers to the tertiary workforce is lucrative starting salaries for top graduates in alternative industries. This acts as a disincentive to have a career in research when considering career options both at graduation (with a comparatively few PhD scholarships) and once they have entered the workforce. Contractual arrangements, HR practices, recruiting cultures and the difficulty in moving easily between higher education and business sectors also contribute to a reluctance of graduates to commit to one sector or another.

Median salaries of research postgraduates of South Australia institutions are generally lower than research graduates from institutions in other parts of the country (for those graduates included in the graduate outcomes survey). The differences are only slight for the fields of education selected in Table 6.10 below.

*Table 6.10: Median salary of domestic postgraduates by year, 2013-19, for selected fields of education, SA and the rest of Australia ($)*

| Field of education | 2013 | | 2015 | | 2017 | | 2019 | |
|---|---|---|---|---|---|---|---|---|
| | SA | Rest of Australia | SA | Rest of Australia | SA | Rest of Australia | SA | Rest of Australia |
| Science and mathematics | 68,000 | 72,000 | 74,000 | 74,800 | 78,600 | 78,000 | 83,300 | 83,000 |
| Engineering | 75,000 | 78,000 | 85,000 | 79,900 | 84,400 | 80,000 | 85,000 | 87,000 |
| Medicine | 88,500 | 82,300 | 81,800 | 83,000 | 80,000 | 90,500 | 85,000 | 87,000 |
| Humanities, culture and social sciences | 74,100 | 77,000 | 76,000 | 80,000 | 68,500 | 70,000 | 63,900 | 66,300 |

*Source: 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.*

Median salaries for science and mathematics postgraduate researchers from South Australian institutions are comparable to postgraduate researchers in the rest of Australia. The data does not describe whether the salaries being earned are in occupations related to the graduate field of education.

One of the key mechanisms in the development of early to middle phases of the careers of researchers are fellowships. Fellowships are used globally in various forms to enable the development of junior researchers, to deliver discrete projects, to contribute to societal and program outcomes and to enable collaboration based on research results.

*Table 6.11: Selected ARC fellowships, SA and Australia, 2009-2019*

| | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | Grand Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SA** | | | | | | | | | | | | |
| ARC Future Fellowships | 9 | 12 | 11 | 14 | 18 | 12 | 2 | 6 | 5 | 8 | 11 | 108 |
| Australian Laureate Fellowships | 1 | 0 | 0 | 0 | 2 | 1 | 0 | 0 | 2 | 0 | 0 | 6 |
| Discovery Early Career Researcher Awards | - | - | - | 18 | 10 | 9 | 16 | 15 | 10 | 10 | 5 | 93 |
| **Australia** | | | | | | | | | | | | |
| ARC Future Fellowships | 200 | 200 | 203 | 209 | 201 | 150 | 50 | 100 | 91 | 100 | 100 | 1,604 |
| Australian Laureate Fellowships | 15 | 15 | 17 | 17 | 17 | 16 | 15 | 16 | 17 | 16 | 17 | 178 |
| Discovery Early Career Researcher Awards | - | - | - | 277 | 200 | 200 | 200 | 200 | 200 | 197 | 200 | 1,674 |
| **SA as % of Australia** | | | | | | | | | | | | |
| ARC Future Fellowships | 4.5 | 6.0 | 5.4 | 6.7 | 9.0 | 8.0 | 4.0 | 6.0 | 5.5 | 8.0 | 11.0 | 6.7 |
| Australian Laureate Fellowships | 6.7 | 0.0 | 0.0 | 0.0 | 11.8 | 6.3 | 0.0 | 0.0 | 11.8 | 0.0 | 0.0 | 3.4 |
| Discovery Early Career Researcher Awards | 0.0 | 0.0 | 0.0 | 6.5 | 5.0 | 4.5 | 8.0 | 7.5 | 5.0 | 5.1 | 2.5 | 5.6 |

*Source: ARC National Competitive Grants Program Dataset (Program statistics do not take into account whether the fellowship was taken up or has been transferred between organisations post-award). Data for 2020 is not complete for the full year and is not shown.*

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.

### *Employer approaches to researcher skills and employment*

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 businesses compete for a smaller talent researcher 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 and employment in the area in which they were educated.

Another implication is the mismatch of the graduate pool with the jobs industry offer in South Australia; this is more common where industries restructure production and where the rate of technological change is high.

The Commission heard from business stakeholders that actively recruit researchers and HDR graduates, that they greatly value research skills, technical skills and knowledge, and the contribution to development of products and services.

The Commission observes a degree of reticence amongst some sections of South Australian businesses to pursue training and recruitment of HDRs and researchers. This arises for several reasons, not always related to employer costs. The prospect of losing talent and skills invested in by business weighs heavily on the decision. The use of researchers and HDR graduates can be desired by business but they may not be able to extract full value from recruitment or mis-assign duties relevant to worker potential. In addition, some firms may be reluctant to undertake collaboration due to the possibility of having HDRs and other researchers poached, resulting in the firm losing knowledge about products or the industry.

Research recently commissioned by Flinders University indicates that industry[103]:

- is generally not aware of the value, expertise and skills associated with HDRs (and equate them with undergraduates) but is interested in the potential productivity and innovation influences of HDRs for their business;
- is interested in HDR research currently undertaken and seeks pathways to connect with students through the university and build relationships;
- desires to engage with researchers who understand their industry; and
- seeks recognition as an equal partner, with relevance, credibility and shared ownership of research.

One of the other issues raised by stakeholders and present in the literature is the importance of relevant industry or business modules in academic qualifications to enable more practical application of knowledge. Common practice in the international context are PhD programs that strike a balance of academia and post-education relevance, containing modules of business practice and application of technologies and product development.

The Commission notes several stakeholder reports identifying 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[104]. More mobility across and within sectors would help stakeholders recognise the value that each party can offer.

The structures and incentives for collaboration between researchers and business find their origins in the interaction between the two sectors during the time graduates are earning their qualification. Questions asked in the Graduate Outcomes Survey in 2018 and 2019 were whether students had felt they had opportunities to develop contacts outside the university sector and whether they had opportunities to work on research problems with organisations outside the university sector.

[103] Flinders University, DR 4
[104] Australian Industry Group, *Joining Forces: Innovation Success Through Partnerships*, Research Report (September 2016).

While the questions were only asked in the 2018 and 2019 surveys, the results are revealing in the level of application of knowledge with industry practitioners or researchers in the field outside universities. 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

Labour mobility between research and industry is another important factor for knowledge transfer between industry and science and is a critical factor in research workforce productivity.

The Commission has not been informed by stakeholders of barriers, regulatory or financial, that prevent mobility between sectors and development of careers and cooperation involving higher education and business. The underlying factors appear to be cultural. In the university sector, they are related to the entry and nature of employment within the higher education sector to gain and secure positions and funding to support ongoing positions. Within the business sector, attitudes to hiring researchers are a factor.

The Commission sees value in broader and deeper engagement between higher education and business to enable graduates to develop relevant industry skills by the time they graduate. 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. This strategy could also support the development of greater capabilities within key research areas of higher education institutions, involving the use of mentoring for early and mid-career researchers.

The Commission can also see the benefits of a partnership between key industries, the universities and government to encourage recruitment of new students into research.

The Commission notes the view of university stakeholders who described a lack of investment currently in both domestic and international student research scholarships, resulting in low numbers of research students. There are opportunities for growth across a range of disciplines; for such a program to be successful the increased graduate output must be met by more employment opportunities using the skills acquired during study. There is scope for system-wide commitment to improving researcher graduate supply and employment opportunities.

***Postgraduate employment***

The Commission examined the possible range of incentives that might be made available to encourage research graduates to work in South Australia. 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 start-up packages and other incentives. The university sector in South Australia has the scope to address and enhance these aspects in its graduate recruitment process.

The University of Adelaide suggested helping to make research degrees more attractive through initiatives encouraging HDR and other postgraduate student involvement across business and government. This policy would also benefit from an accompanied increase in public messaging and support to promote the value that the economy can gain from engaging with or hiring postgraduates, and the value of undertaking such degrees.

Other potential policy gaps and programs identified by the university sector involving state government, university and industry partnerships include:

- enhancements to the platform to assist universities to advertise their funded postgraduate scholarships locally and internationally in one central location;
- incentives for industry-linked PhDs to help increase the education levels of the workforce as well as improve and foster linkages between industry and universities for R&D; and
- support programs that extend beyond PhD scholarships, including support for postdoctoral studies and support for existing workers to undertake postgraduate studies.

The Commission notes the position of some small businesses for enhanced support in the future to take up and engage graduate researchers as well as enable employees with research skills within business to collaborate and interact with the research community. There may also be scope for the state government, as a major employer, to support more research skill positions with the public sector. Such a program however should only be considered with the necessary pathways to meaningful employment in private sector research activity in the long-term.

An initial conclusion is that there may be merit in facilitating the placement of PhD graduates in projects and activities of strategic value to the state. The Commission will consult with stakeholders on these conclusions and provide recommendations in the final report.

***Academic workforce***

There is a lack of data on the R&D workforce outside of the Higher Education sector. South Australia has the fourth highest number of academic staff per capita in Australia and the fifth highest number of postgraduate students. Estimates of the proportion of researchers by sector in Australia suggest that around 46 to 52 per cent of researchers work in the higher education sector and between 23 to 42 per cent in business.

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[105]. 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.

To support growth in this area, the state government has the option of supporting industrial PhD programs to ensure more engagement of HDR students with business throughout the time of their qualification. An example of an initiative in this regard would be offering incentives for businesses to jointly fund HDR students on selected collaborative projects. Such an initiative would be in line with 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 will consult further with stakeholders on these matters.

**Information Request 6.1**

The Commission seeks stakeholder views on the value of:

- enhancements to the platform to assist universities to advertise their funded postgraduate scholarships locally and internationally in one central location;
- incentives for industry-linked PhDs to help increase the education levels of the workforce as well as improve and foster linkages between industry and universities for R&D;
- growing support programs that extend beyond PhD scholarships, including support for postdoctoral studies and support for existing workers to undertake postgraduate studies;
- enhanced support in the future to take up and engage graduate researchers as well as enable employees with research skills within business to collaborate and interact with the research community;
- facilitating the placement of PhD graduates in projects and activities of strategic value to the state; and
- the state government, as a major employer, supporting more research skill positions with the public sector.

## 6.2. Collaboration

### 6.2.1. Introduction

Analysis undertaken for Universities Australia estimated that $10.6 billion a year in business revenue results directly from partnering with universities, contributing $19.4 billion a year to Australia's income. The employment effects are considerable with business to researcher collaboration adding an estimated 30,000 full-time positions nationally[106].

A 2016-17 survey identified that nearly one in five innovation-active businesses (18 per cent) collaborated with others when innovating. In terms of collaboration with a research organisation, 4.8 per cent of innovation-active businesses in Australia collaborated with a

[105] See: https://www.veski.org.au/fellowships
[106] Universities Australia (Cth), *Clever Collaborations: The Strong Business Case for Collaborating with Universities* (2017).

university, 3.7 per cent collaborated with a not-for-profit organisation and 1.7 per cent collaborated with a government or public research institution.[107]

However, survey evidence suggests that Australian innovation-active businesses report relatively low rates of collaboration on R&D. Over the last ten years, an average of around 5 per cent of Australia's innovation-active businesses collaborated on R&D, with little change over this period. 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 per cent of innovation-active medium sized businesses and 3.5 per cent of innovation-active small 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.[108]

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 (Q4) of the OECD for industry-research collaboration.[109]

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.

*Box 6.1: Case Study 4 – Excellence in research collaboration*

**Myriota**

Myriota is an Internet of Things (IoT) company based at Lot Fourteen, developing low cost, low power technologies. Myriota was founded in Adelaide in 2015 as a spin-off from the University of South Australia.

The company has collaborations across the state, with universities and with local space technology companies Inovor and Neumann Space. It is also a member of the SmartSat CRC which is headquartered in SA. Myriota has received investment through the South Australian Venture Capital Fund and in 2020 completed a $28 million Series B funding round. The company attracted funding from Australian venture capital firms Main Sequence Ventures and Blue Sky Venture Capital as well as Boeing HorizonX Ventures, Singtel Innov8 and Right Click Capital.

Myriota has furthered its partnership with Canadian data services company exactEarth to acquire satellite communications assets.

*Source: Office of the Chief Scientist and https://indaily.com.au/news/business/2020/04/07/myriota-raises-28-million-to-expand-satellite-fleet/*

[107] Australian Bureau of Statistics, Innovation in Australian Business 2016-17, ABS Catalogue No. 8158.0.
[108] Australian Bureau of Statistics Characteristics of Australian Business, Catalogue Nos. 8129.0, Cat. No. 8158.0, Cat. No. 8166.0, Cat. No. 8167.0
[109] 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.

### 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[110], 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.

For example, informal channels of knowledge transfer (e.g. networking, facility sharing, and on-the job training) are often very important for those SMEs with limited ability to engage in more formal channels of collaboration. Similarly, high, medium and low-technology sectors behave very differently with respect to knowledge transfer and require different incentives. Low technology sectors often have fewer linkages with universities and less staff with a science background; that requires more effort to establish linkages with industry, and to start a process of collaboration between the industry and universities.

The common thread of collaboration models outside Australia is public investments to generate economic growth driven by 'additionality' which is usually geared towards societal problems, technical challenges and the economic 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 the private sector would have done without support.

Other models concentrate on the gap between early stage publicly funded basic research and privately funded research at the latter end of commercialisation

Some governments provide assistance to technology transfer offices of universities in the form of finance for commercialisation, such as in the United Kingdom under University Challenge funding. In the United States, on the other hand, most funding comes from private sources with the encouragement of government through schemes such as the Small Business Innovation Research Program (SBIR) and the Small Business Technology Transfer Program (STTR).

From the university perspective, some entities have committed substantial capital funds through the invention-innovation cycle from early to mid-stage development through to venture capital to bring an idea to market. Other models range from concentration on spin-off companies from the university to commercialisation through wholly-owned companies.

One constant theme in knowledge transfer activities of universities, particularly in the United States, is the dominance of life sciences with the other significant fields being physical sciences and engineering, and ICT. A biotech company or an IT company attract venture capital interest due to the higher rates of growth and higher valuations of cashflow, earnings, revenue and deal flow.

The caveat to those findings is that many of these models come from economies, regions or trading blocs that are very large, with large corporations and exceptional research institutions. It would perhaps be more difficult for these relationships not to occur than to occur given the extent of industry integration with institutions, competition for research grants, application of knowledge and number of globally connected firms.

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[110] OECD, *University-Industry Collaboration: New Evidence and Policy Options* (OECD Publishing, Paris 2019).

### 6.2.3. Research institution and industry collaboration

Such collaboration refers to the interaction between any parts of the higher education sector (including universities, colleges, research institutions and centres) and industry, aiming mainly to encourage knowledge and technology exchange[111].

The focus of research institution and industry collaborations covers all aspects of the research, development and innovation chain from knowledge creation through to translation and transmission to commercial adaptation, technology adoption and innovation of processes and products. Factors that facilitate or impede the operation of research institution and industry collaboration are summarised in Table 6.12.

*Table 6.12: Factors facilitating or impeding research-industry collaboration*

| Category | Factors |
|---|---|
| **Capacity and resources** | • Adequate resources (funding, human and facilities)<br>• Incentive structures for university researchers<br>• Recruitment and training of technology transfer staff<br>• Capacity constraints of SMEs |
| **Legal and contractual matters** | • Inflexible university policies including IP rights, patents, and licenses and contractual mechanisms<br>• Treatment of confidential and proprietary information |
| **Management and organisational issues** | • Leadership, commitment and communication<br>• Teamwork and flexibility to adapt<br>• Corporate stability<br>• Project management<br>• Organization culture (cultural differences between the world of academia and of industry)<br>• Organization structure (university and firms)<br>• Firm size (size of organization)<br>• Absorptive capacity<br>• Skill and role of both university and industry liaisons<br>• Human capital mobility/personnel exchange |
| **Technological issues** | • Nature of the technology/knowledge to be transferred (tacit or explicit; generic or specialized; academic rigor or industrial relevance) |
| **Policy** | • Policy, legislation and regulation to encourage collaboration (includes tax credits, information networks and direct advisory assistance to industry) |
| **Other issues** | • Enhancement in reputation/prestige<br>• Low level awareness of university research capabilities<br>• Use of intermediary (third party)<br>• Risk of research<br>• Cross-sector differences/similarities<br>• Geographic proximity |

*Source:* Samuel Ankrah and Omar Al-Tabbaa, 'Universities-Industry Collaboration: A systematic review' (2015) 31 *Scandinavian Journal of Management,* 387-408.

[111] Samuel Ankrah and Omar Al-Tabbaa, 'Universities-Industry Collaboration: A systematic review' (2015) 31 *Scandinavian Journal of Management,* 387-408.

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 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 critical infrastructure (in the form of incubation centres or innovation parks);
- providing innovation support services for enhancing commercialisation; and
- ensuring policy, legislation and regulation supports and encourages collaboration.

### 6.2.4. 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***

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 NanoConnect and the PRIF, under which a number of collaborative programs are administered.

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 of the consortia supported have not been realised; however, some of the outputs to date include:

- The Registry of Older South Australians (led by SAHMRI) developed an Outcome Monitoring System for quality and safety benchmarking within aged care facilities. It has been shared widely with the Australian Government Department of Health, all national aged care peak bodies, aged care providers and collaboratives of providers, and the Royal Commission into Aged Care Quality and Safety.
- The Unlocking Complex Resources through Lean Processing Consortium (led by the Institute for Mineral and Energy Resources, University of Adelaide) was successful in attracting a $3.7m ARC Training Centre for Integrated Operations for Complex Resources to South Australia. The training centre will help to develop the future mining workforce in collaboration with industry’s needs.

***University perspective***

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 start-ups; 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 two used for leveraging grants;

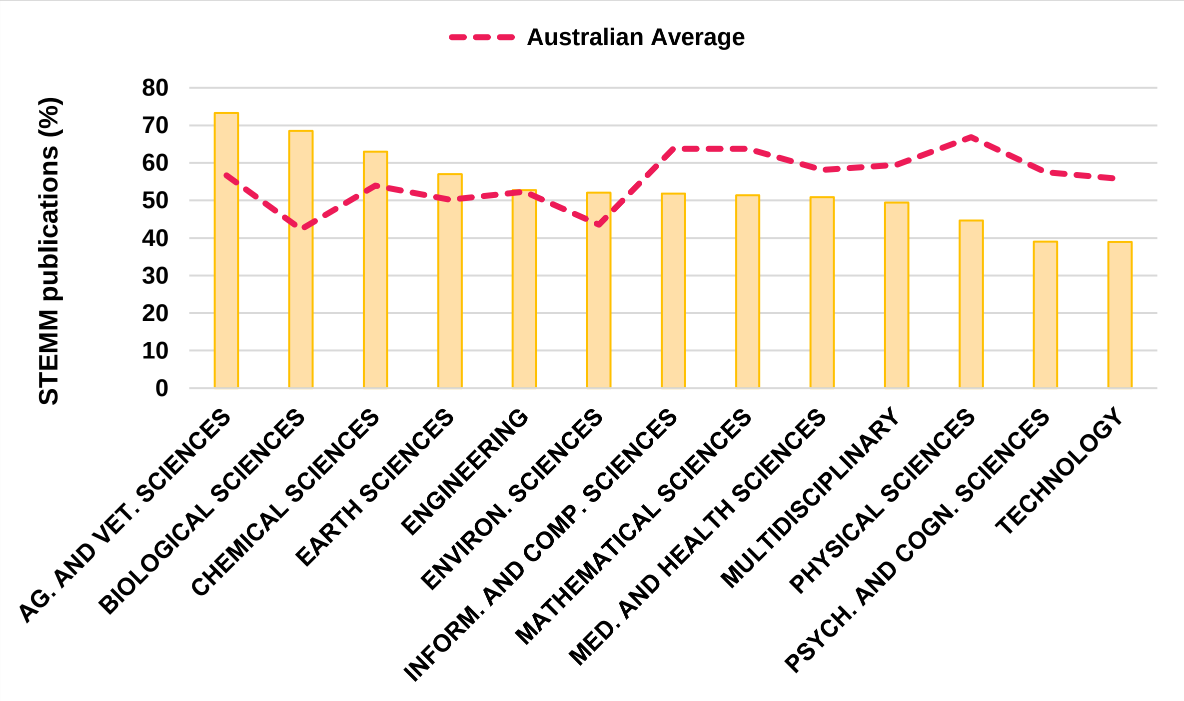
- An additional 20 patents are managed by licensees; and
- Not all licences have a patent associated with them. Of 117 active licences, approximately 50 do not have a patent associated with them.

<u>Publications data: collaboration through co-authorship</u>

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 6.11 indicates that South Australian researchers undertake higher than Australian average collaboration with international co-authors in a number of fields including agriculture, biological sciences, chemical sciences and earth sciences.

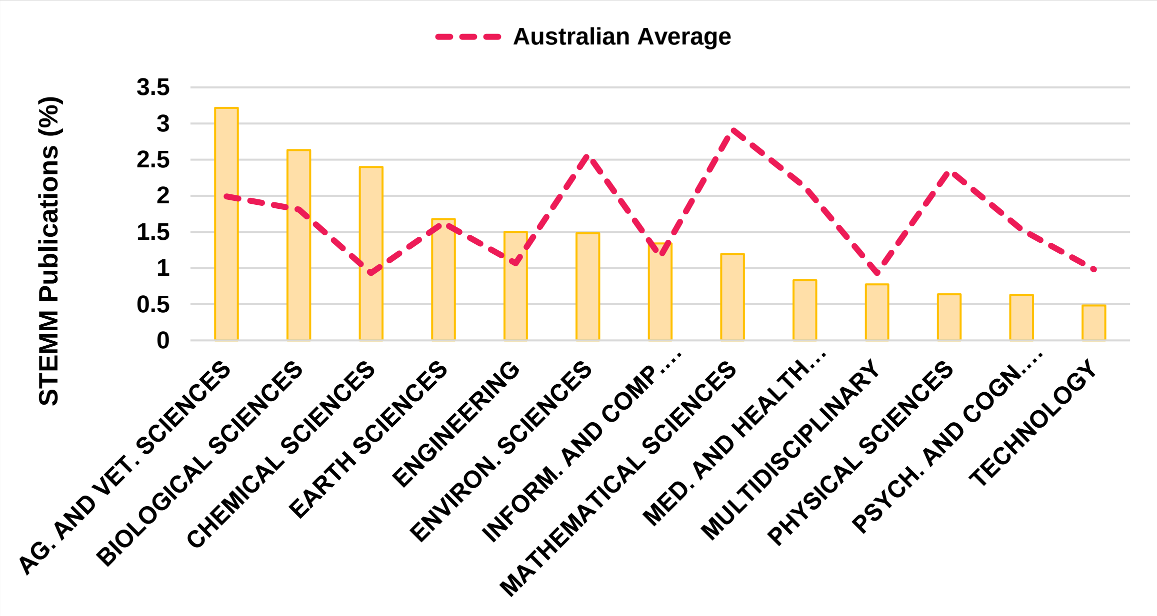
*Figure 6.11: Proportion of STEMM publications with international co-authors, SA, 2009-18*




*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, South Australian researchers again outperform the Australian average on agriculture, biological, chemical and earth sciences and engineering.

*Figure 6.12: 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.*

<u>Engagement and Impact assessment</u>

The ARC conducts the Engagement and Impact (EI) assessment, which is a companion exercise to the ERA. The EI assessment examines how universities are translating their research into economic, environmental, social, cultural and other benefits.

The EI is based on an engagement narrative presented by the universities on their research engagement activities and indicators of research engagement. Universities are required to describe the overall engagement activity, strategies and/or objectives for the research units of assessment over a three-year period. The engagement narratives cover:

- collaboration with strategic stakeholders;
- public participation (citizen science);
- providing specialist resources and services to external stakeholders; and
- provision of specialist training or trainee programs.

The compulsory indicators of research engagement with end-users are:

- cash support from research end-users;
- HERDC research income;
- proportion of specified HERDC Category 1 grants to total HERDC Category 1 grants (including grant amount and number of grants); and
- research commercialisation income.

The first results of the EI were presented in 2018 and as such the indicators and its influence is still being established. The results for South Australia are presented in Table 6.13.

*Table 6.13: Engagement and Impact assessment results, 2018, South Australian universities*

| Field of research | Adelaide University | | | Flinders University | | | University of South Australia | | |
|---|---|---|---|---|---|---|---|---|---|
| | Engagement | Impact | Approach to impact | Engagement | Impact | Approach to impact | Engagement | Impact | Approach to impact |
| Mathematical Sciences | High | High | High | NA | NA | NA | High | High | Medium |
| Physical Sciences | Medium | Low | Low | Low | RNTA | RNTA | NA | NA | NA |
| Chemical Sciences | Medium | Medium | Medium | High | Medium | Medium | High | High | High |
| Earth Sciences | High | Medium | Low | Medium | High | Low | NA | NA | NA |
| Environmental Sciences | High | Medium | Medium | NA | NA | NA | Medium | High | High |
| Biological Sciences | High | High | Medium | Medium | High | Medium | Medium | Medium | High |
| Agricultural and Veterinary Sciences | High | High | High | Medium | Medium | Medium | NA | NA | NA |
| Information and Computing Sciences | High | High | Medium | High | Medium | High | High | High | High |
| Engineering | High | High | High | Medium | Medium | High | High | High | Medium |
| Technology | Medium | Medium | Medium | High | Medium | High | NA | NA | NA |
| Medical and Health Sciences (Biomedical and Clinical Sciences) | High | High | Medium | Medium | High | Medium | High | Low | High |
| Medical and Health Sciences (Public and Allied Health Sciences) | High | High | Medium | Medium | Medium | Low | High | High | High |
| Built Environment and Design | High | Medium | Low | NA | NA | NA | High | High | Medium |
| Education | Low | Low | Low | Medium | High | Medium | Medium | High | Medium |
| Economics | High | High | Medium | NA | NA | NA | Medium | High | Medium |

| Field of research | Adelaide University | | | Flinders University | | | University of South Australia | | |
|---|---|---|---|---|---|---|---|---|---|
| Commerce, Management, Tourism and Services | Medium | High | Medium | Medium | Medium | Medium | High | High | High |
| Studies in Human Society | Medium | Medium | Medium | Medium | Medium | Medium | High | High | High |
| Psychology and Cognitive Sciences | High | Medium | Medium | Medium | Medium | Medium | Medium | Medium | Medium |
| Law and Legal Studies | High | High | High | Medium | High | Medium | High | High | High |
| Studies in Creative Arts and Writing | Medium | Medium | Low | Medium | Medium | Medium | NA | Medium | Low |
| Language, Communication and Culture | Medium | High | High | Medium | Low | Low | Medium | High | Medium |
| History and Archaeology | Medium | Medium | Low | Low | Medium | Medium | NA | NA | NA |
| Philosophy and Religious Studies | High | RNTA | RNTA | Medium | Low | Low | NA | NA | NA |
| Interdisciplinary Research | | High | High | | Medium | Medium | | High | High |
| Aboriginal and Torres Strait Islander Research | | High | High | | NA | NA | | High | Medium |

*Source: Australian Research Council*

*NA = Not assessed due to low volumes*

*RNTA = Requested by the institution not to be assessed*

***Industry assessment of outcomes – primary industries***

The Commission received information regarding collaboration that predominantly relates to primary industries. The Commission will investigate further into collaboration in other sectors. The following discussion is confined to the evidence and views received to date.

The models of collaboration are generally founded 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 different forms of measurement which are mainly qualitative.

The Crop Science Society of SA considered that the extension activities of key R&D outputs have led to improved gross production as well as an increased efficiency in highly competitive markets and changing environments.

Livestock SA advised the Commission of the benefits related to 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 to the state with links to the national Meat Industry and Sheep Industry Strategic Plans (MISP & SISP).

The blueprint also helped facilitate the Red Meat and Wool Growth Program, which included the SA Government committing $7.5 million in investment to grow the SA sheep industry with governance from representatives of each sector directing input into the development of the program.

South Australian research groups have been leaders in national research and development in the meat and sheep industries influencing outcomes both in South Australia and nationally in accordance with the objectives of the blueprints.

The blueprint has fostered research and development projects which are exploring different aspects of the value chain. One such project is microbial prevention and carcass composition using measurement of bone density through spectral imaging, a practice which is now applied commercially in abattoirs in South Australia. Other projects include: improving genetics using data from abattoirs, improved consumer approach to packaging in retail outlets, imaging analysis technology for animal reproduction as well as animal welfare issues arising from on-farm, live export and transport practices.

In the water industry, the Goyder Institute has successfully fostered collaboration between researchers and end-users. The collaboration 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 has achieved a highly cooperative approach to identifying water knowledge gaps, targeted research projects and direct adoption pathways. Importantly, the model has 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 considers that in recent years, the funds set aside for R&D have not achieved benefits for the industry. The association states that reforms are needed to address:

- the lack of significant industry input into identifying research priorities with the focus in recent years restricted largely to biological R&D. The priorities are identified by government and then taken to industry for discussion leaving little room for collaboration on other industry priorities such as marketing, processing innovation, packaging, and fishing equipment development.
- the inability for industry to use R&D providers other than the government mandated organisation, SARDI, for biological research on fish stocks. This has implications for resources and charges in the delivery of the R&D, which is seen as expensive when compared to potential alternative providers.
- the differing objectives of industry and the state government. The industry's focus is on achieving a profitable industry based on sustainable fish stocks whereas the state government focus in their view is on the management of the fish stocks without the long-term focus on industry sustainability.

Suggested reforms by the Marine Fishers Association include greater collaboration on industry research priorities and that the competitive nature of research projects tendering be improved to open the process to private sector firms.

### 6.2.5. 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.

In a practical sense, there is a greater need for more coordination across industry accelerators and support for business in ventures, with more support for firms in the phase shortly after start-up.

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.

In terms of collaboration reform, the university sector saw significant opportunities for universities in South Australia to align projects to state priorities in all fields including science, humanities, arts and policy. It argued this would enhance the research strategy of the university sector which relates to industry-driven questions and future challenges of society. The university sector acknowledged the fundamental recent change in how it engages with industry in terms of its engagement language and focus on practical outcomes for the business.

Some stakeholders identified protective intellectual property practices by both businesses and the university sector as a barrier to collaboration. Other stakeholders said that ownership of IP was less of an issue for small business than rights to use IP when involved in CRCs. When involved with a university through a CRC it is often simpler if the University owns IP, but when raising capital, it is more advantageous if IP is owned by the company.

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.

### 6.2.6. Findings

The Commission was told by business stakeholders that collaboration programs and networking are not sustained on a long-term and meaningful basis. Once business contacts are placed on committees or are made part of collaborative structures and programs, tangible outcomes do not readily occur.

The experience in South Australia suggests that collaboration can lose traction and momentum is lost over the long-term because other priorities take over for all parties. There are difficulties in industry working with research. Some universities have KPIs associated with publication output, some have KPIs for leveraging industry funding.

The academic, industrial and policy environment is also important for South Australia in determining the best ways to promote and improve levels of collaboration. From the evidence provided to the Commission, the coverage of knowledge transfer is confined to a narrow number of mechanisms, in traditional sectors or sectors in which South Australia does not have a competitive advantage.

There appears to be greater scope for collaboration activities of value beyond that which occurs currently, meeting 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.

The second part of the findings of this section relate to cultural issues around collaboration. The Commission heard from stakeholders that business and the research sector do not know how to engage with one another. In some respects, industry finds universities large, formidable organisations that make it difficult to know where to start engagement.

There are a range of projects involving business-researcher collaboration that have a research element and there are projects that do not. This can mean poor alignment of incentives for collaboration. In some cases, businesses merely require access to literature and assistance with dissemination of data and information. Where there is a commercial aspect to the collaboration, the outputs are not likely to include academic publications.

Further to this, any future research opportunities emerging from commercial projects might not be realised due to lack of interest or no mechanism within the university to alert other faculties to the work. For units within the university with a more practical collaborative approach to engagement, measurement of success is not related to research papers. Where collaborative research papers are produced in areas of interest to these units, this occurs independently via work from other university faculties. These units are bridges between industry and universities, and they help other sectors access enabling technology not otherwise in reach, an example is the AIML.

The Commission notes that academic outputs are not the principal motivator in many collaborative models in Europe and the United States. This is a fundamentally different focus from the Australian context and sets these organisations apart in terms of collaboration strategies and 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.

In the Australian context individual discretion and research curiosity appear to be the main determinants of collaboration. Potential collaborators need to differentiate 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.

### 6.2.7. Conclusions

Policy needs to allow for a wide variety of collaboration channels and should not overemphasize one single channel such as patents, spin-offs or contract research. Knowledge transfer instruments that have been at the centre of attention of policy makers - particularly university patenting and activities by technology transfer offices - do have their own role, but overall, they are only a small part of knowledge transfer and often do not have all of the requisite features to enable industry to extract value for knowledge transfer, for example in product development.

Mechanisms such as the widespread availability of scientific journals, as well as encourage participation in scientific conferences for larger and smaller industrial firms, could be much more effective to support firms’ awareness of newly developed knowledge. Moreover, recruitment of skilled students as well as promoting support for postgraduate programs could provide benefits for firms needing to absorb academic knowledge into their products, processes and organisation.

The Commission sees value in 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 could do more with good outcomes, and it needs to do more on a much larger scale and on a sustained basis to reap the benefits.

The Commission considers that the mix of state government programs, university activities and Australian Government support can be better coordinated and targeted to deliver better outcomes. The Commission does not rule out the use of instruments that imply large-scale or long-term financial commitments. These instruments are put into place in large-scale, globally integrated and historically strong markets, which is not the case in SA.

**Information Request 6.2**

Participants are invited to provide their views on the scale and type of collaboration mechanisms, either discussed in this section or preferably based on experience and insight, best suited to the South Australian context.

If policy aims to successfully increase the impact of academic research through fostering engagement, not only universities but firms too need to be skilled in initiating and maintaining such collaborations, recognising that collaborating with academia presents distinct challenges for firms, separate to those of customers or suppliers.

The Commission has heard that visibility and accessibility to schemes are important. 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 BioInnovation 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.

There may be scope for re-introducing such programs to facilitate connections and networking between key groups in the commercialisation life cycle as another policy option available to state government to influence commercialisation outcomes.

The Commission is sympathetic to the idea of reforms that establish a platform for industry and researchers to bridge informational and cultural barriers. Such platforms are in the context of broader collaborative models discussed in this section. 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 measure.

These mechanisms can take the form of industry-funded positions, an endowed chair, seed funding for research or state government sponsored brokerage services. The Commission notes that in the US, such services are funded by states as they are deemed important enough to be supported by the state government.

There is still much to consider, and the Commission seeks further information from stakeholders on the benefits and disadvantages as well as some of the interplays and practices of knowledge transfer policies.

**Information Request 6.3**

The Commission invites insights from stakeholders based on their experience and knowledge on:

- the type of intermediary organisations and responsibilities that are appropriate considering the state's structural and institutional characteristics; and
- whether intermediary organisations should have an industrial focus and be specialised in specific technological niches or build new collaborations across disciplinary and geographical boundaries.

# 7. Concluding analysis and ways forward

This inquiry is about options to increase R&D activity and the factors which influence the extent R&D translates into economic growth. Broadly, the Commission has been asked to: examine the role and settings of policy levers available to the state government; assess the effectiveness of various government interventions aimed at increasing R&D efficiency and outputs; and recommend actions the government can take on those matters (including advice the state can give to the Australian Government).

In the preceding chapters, the Commission has presented a wide range of evidence to report on and assess the state's R&D performance with consideration of the various factors that support or inhibit R&D activity in this state. This chapter is a synthesis of that evidence and discusses ways forward for policy design. As this is a draft report, it represents the Commission's preliminary views, which will be refined as this inquiry progresses. The Commission invites feedback and additional information from R&D sector participants and other stakeholders ahead of completing our final report.

This chapter is structured as follows:

- Section 7.1 provides conclusions on the state's R&D performance, drawing from the evidence presented in earlier chapters, and makes observations on the effectiveness of policy.
- Section 7.2 puts forward principles on good R&D policy design and discusses some specific actions the SA Government could take to improve R&D policy.

The Commission proceeds from the view that that technological (and other) progress plays a key role in lifting national productivity and economic output. In turn, these gains can translate to income growth and the enhanced wellbeing of individuals and communities. That said, the link between R&D policy and economic performance is not straightforward — many factors, including complex systems of production and innovation that exist in the functioning of markets (and not wholly within the control of government), work together to influence economic outcomes.

The Commission has not reached a conclusion on an optimal level of R&D for SA. Making such an assessment is notoriously difficult. Instead, this chapter presents a synthesis of the information relating to SA's relative strengths and weaknesses over time, and in relation to other states, and discusses implications for the formulation and assessment of state R&D policy. In making our recommendations, the Commission seeks to give effect to the Government's objectives in initiating this inquiry, which are to ensure that R&D policies are evidence-based, and well designed, to maximise their impact.

## 7.1 Analysis of SA's R&D performance and the effectiveness of policy

### 7.1.1 Business sector

The business sector spends around $800 million a year on R&D in SA. Based on the evidence presented in this report, the Commission concludes that SA businesses invest in line with expectations, allowing for industry structure and the size and distribution of firms. To break this down further:

- 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).

- 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.

Nonetheless, business expenditure on R&D in SA has declined since 2011-12 as a percentage of GSP, as it has for all jurisdictions. Business R&D expenditure is also concentrated in a small segment of the SA economy; in 2017-18, approximately 60 per cent of business R&D expenditure came from two areas – professional, scientific and technical services (34.5 per cent) and manufacturing (24.7 per cent).

Although data measuring industry and research sector collaboration is scant, evidence collected by the Commission suggests that SA's collaboration performance is also not out of step with other states. SA businesses are just as likely as their interstate counterparts to apply for a patent with another party. In terms of academic collaboration with international or industry co-authors, SA academics perform above the national average in the fields of agriculture, chemistry and biological sciences. However, the Commission notes that Australia overall has a poor track record on research collaboration with industry, according to analysis by the OECD, and feedback from participants to this inquiry suggests this is an area where there is substantial scope for improvement in SA.

An important consideration is the alignment of areas of research strength on the one hand and industry structure on the other. There is likely to be a two-way relationship between research and industry structure. Strong research performance may lead to the evolution of industry structure, but at the same time research which is aligned to local industry concentrations is ultimately likely to be more productive in its impact on downstream jobs and the South Australian economy.

A framework for making informed choices among the sectoral priorities in research is important and, in the Commission's view, is a current gap in South Australia's policy framework. Despite extensive research and consultation, there is little evidence of the existence of this type of framework in SA.

The Commission notes that, in this context, there is always a question about the benefit of investment in research, since not all the benefits are captured locally (also flowing to the rest of the country and the rest of the world). However, that 'street' carries two-way traffic. The presence of high-quality research groups also assists in the translation of research from the rest of the world into local practice, including through education and training. For instance, in this report, attention is given to the international and domestic evidence on the value of placing PhD graduates into business. The Commission considers that deeper business engagement into what, and how, local research is undertaken can add to the scale, productivity and quality of that effort. It can also facilitate the translation of research into practice, help capture value in local conditions and provide some 'first mover' advantages.

Another perspective on these issues is the timeframes involved. Generally, there are long lags from basic research to application. Studies in the agriculture sector for example find lags of decades. Consultations pointed to the current strength in some digital technology areas being based on research done decades ago. This situation has implications for the origins of business growth. The Commission recognises that there is, clearly, opportunity to build brand new businesses out of local research endeavours. Some important examples exist and there is scope for a contribution to growth through this channel. But it is not a plausible scenario, in the Commission's view, to rely on growth in SA through this channel. This outcome will be protracted, given the timeframes involved. And a high-performing research sector may encourage existing businesses to grow or locate some of their operations in South Australia.

These investments, alongside the local research system, are also likely to involve the movement of people, either directly within the business involved, or between the research partners. Success then depends on the other factors that influence people mobility, which include the quality of urban amenities.

### 7.1.2 Higher education sector

The state's three public universities continue to be an important source 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 has outstripped growth in business R&D and government R&D expenditures both nationally and in SA.

Nevertheless, here are some signs that the research strength of SA's higher education providers has weakened in recent years and compared with 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.
- The funding received by SA universities from the Australian Government via competitive grants grew 4.3 per cent year on year between 2006 and 2018, but its share relative to funding provided nationally has dropped from 8.9 to 8.1 per cent over the same period.
- Since 2014, average grants for SA universities have been lower than the Australian average.

Taken together, this evidence suggests that SA's universities are becoming less effective at competing for Australian Government research funding.

The Commission notes that total ARC competitive grants are lower than they were in 2014 both nationally and in SA. For South Australia, the decrease is compounded by the fact that the state's share in ARC competitive grant funding has also been falling (see Table 3.6). This is a matter of concern because it is a relatively big source of research funding in South Australia.

The Commission also notes the reliance of the higher education sector on supporting research through its own funds, which occurs via teaching cross-subsidies. Noting that this share of funding is lower in South Australia when compared to other states, the Commission notes the uncertainty associated with this funding source, because of the implications from the response to the COVID-19 pandemic for cross-border movement of students. This situation is a significant weakness in research funding nationally. 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 activity in the local research system.

High level indicators of higher education research performance are outputs (usually measured by publications) and their quality. The Commission finds that with respect to the latter, several fields perform at global best levels. However, the scale, measured by staff, of some of these areas is relatively small, leading to a concern about the fragility of performance.

This state-wide picture of higher education research shows the large focus on the field of health and medical research (HMR). South Australia is not an outlier in this respect compared to the rest of Australia, given policy priorities and resources from the Australian Government. That said, the state is an outlier in the share of the national research workforce in HMR, which is relatively high. The SAPC in the draft report of a concurrent inquiry into that sector has separately considered the delivery of research in this field in SA and its productivity. The final report into this inquiry will incorporate the findings, conclusions and recommendations of the HMR inquiry. Other fields in which SA shows a relatively high level of concentration of workforce include biological sciences and agriculture and veterinary sciences.

With respect to inputs to the research process, the Commission has examined not only expenditure data but also workforce data.

In terms of the research workforce, the number of person years of effort devoted to R&D has fallen over the period 2012-2018 from 2,067 to 1,848, compared to an increase in Australia as a whole (23,305 to 24,805) over the same period. Using ERA headcount data, staff numbers increased in SA over the same period, which appears to suggest the use of more part-time staff in research and/or more time allocated to teaching or other duties. The Commission is interested in views on the impact of the declining workforce effort on R&D activity in the higher education sector, noting the different degrees of labour intensity in research across fields.

The Commission is concerned about the composition of the research workforce, especially succession risks in research leadership in the higher education sector. Agriculture is an example; it continues to show high performance by most indicators, but the Commission has a question about whether it is now vulnerable to the loss of ‘stars’. 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).

As noted, assessments of higher education research performance often consider output indicators such as publications. However, not all outputs are of equal value in the long run, and some further adjustment may be needed to take the quality of outputs into account. For example, a proxy measure of the quality of publications is the extent to which they are cited. The Commission compiled data on the share of papers from South Australia that are included in the top 1 per cent and the top 10 per cent of papers cited world-wide. Generally, these shares have a high association with each other but in some cases, in South Australia, the top 10 per cent share is much lower than the share in the top 1 per cent. This may be an indicator of limited depth of talent in local research in this field and the Commission seeks further commentary on this view.

The productivity of the research efforts also matters, particularly the staff time and other inputs used to produce those outputs. Taking these points into account, the Commission sees merit in developing measures for the research sector and using them to benchmark local performance. Such work also supports assessments of the international competitiveness of various fields of research, based on indicators of productivity and scale that can inform investment decisions.

### 7.1.3 Government sector

The Australian Government is a major participant in R&D activity within this state, both as a funder and through its own expenditure. In 2018-19, approximately 16 per cent of Australian Government expenditure on R&D occurred in South Australia, with only Victoria having higher Australian Government expenditure. 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 partly due to the significant presence of DST. Since 2006-07, intramural Commonwealth expenditure on R&D in South Australia has 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 Australian Capital Territory 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.

The SA Government has been active on R&D policy for many years. The policy mix includes in-house spending, grant programs (including forms of procurement), precinct investments and other activities promoting cooperation and collaboration among various research organisations. The state also owns significant research assets.

State government expenditure on R&D is a key element of its policy mix. One component of that spending is that reserved for its own agencies, including the research portfolios of DHW, PIRSA, SA Water, DIS and DEM. It has also funded specialist research groups, including SARDI, BioSA (until recently) and SAHMRI among others.

The Commission has, in a first for the state, compiled estimates of the state government's spending on research and development over the past six years. The state manages a significant amount of spending, especially through its agencies, of the order of $120 million annually. A significant portion of this spending is funded from the state budget with the balance coming from Australian Government agencies, including rural research and development corporations.

This data is not readily available. That the Commission had to undertake this task is a reflection of the way research and development has been considered and managed from a policy perspective. It also reflects a lack of strategic treatment of research spending over the past two decades, notwithstanding stated policy priorities and objectives.

### 7.1.4 Assessment of SA Government R&D policy and links to productivity

Overall, there is a significant amount of research activity being undertaken in SA each year. The Commission estimates this to be in the order of $2 billion (now at about 1.9 per cent of GSP). South Australia has relatively lower levels of business and private non-profit expenditure on R&D than Australia as a whole, and higher levels of government expenditure in R&D.

The Commission examined SA government policy over the past two decades as part of the context of this inquiry.

The state government contributes to research activity through its own research spending and policy and program actions by its own agencies. The contribution of some of these agencies has been significant: SARDI is an important example. But questions remain, including whether the management of that research has crowded out other providers, whether that research could be organised in other collaborative ways, and whether such reforms would increase overall research activity. The Commission considered the impact of several research programs (not related to spending directly on research). The Commission identified the objectives of these programs and tried to compare them with outcomes, using Commission data or using external reviews by others. As an example, the Commission has observed that SASP targets tended to shift over time, making it difficult to assess progress and that it is unclear if most targets were met. This assessment is confounded by the very limited data available to evaluate the stated outcomes.

In particular, the Commission is assessing the effectiveness of precinct projects, such as Tonsley, which represent a substantial investment of state funding over the past two decades. A qualitative assessment has been completed and, in the lead-up to the final report, the Commission will attempt to gather sufficient data for a more quantitative assessment.

With respect to existing precincts, in order to assess their impact, it is essential to understand their purpose. Precincts are directed to several purposes, of which stimulating research is one and innovation (not the subject of this inquiry) is another. The Commission considers a greater likelihood of success in R&D and innovation depends on the specification of the objectives and governance structures. As a result, better returns are possible, through better cooperation of organisations present at the precinct and those located elsewhere who might benefit from a deeper engagement.

Recent developments raise more fundamental questions about the precinct strategy. In many studies, it has been argued that proximity matters for the sharing of ideas and knowledge. The Commission notes that a lot of the research underpinning this advice was undertaken before the growth of fast high bandwidth digital communication and, of course, before the COVID-19 pandemic and the experience of the shift to remote working.

Furthermore, the Commission is concerned that much of the information on precincts to which it has access, lacks data on their costs and most importantly their benefits. The Commission accepts that there is value in proximity but the cost of generating that outcome also matters. If virtual precincts and virtual collaboration are now becoming more culturally acceptable, viable and potentially normal amongst modern knowledge workers, then the cost of virtual vs physical precincts must now be part of their assessment.

This illustrates the bigger issue of the choice between investing in infrastructure and other alternatives. The question always worth asking is how could the resources be better deployed? One option is to develop higher-performing researchers locally or recruiting them into SA. In practice, the best answer is a mix of both. The Commission remains concerned about a bias to infrastructure, and the lack of a framework with a longer timeframe that considers all options.

As in the case of the Commission's work on science and innovation precincts, a common problem in assessing R&D programs and policies is the lack of appropriate data. Reviews have been undertaken, in some cases, but the overall picture is very limited based on the Commission's review of material received.

The linkages of policy and performance have also been examined, looking for shifts in research system performance indicators (such as grant income, business spending, etc.) associated with spending and policy. Despite the continuing relatively high level of activity in the state, the Commission can see little association, at least in its current selection of performance indicators. Indeed, more concerning is the decline in some factors of performance, especially success in systems of competitive grants. Of course, the counterfactual is difficult to define in these circumstances and the Commission seeks feedback on the association of policy activity and R&D system performance.

Another challenge to assessing the contribution of SA Government R&D policies to impacts is that they are not the only contributors to R&D performance, since the contribution of the research institutions (including universities) also matters. Their performance (where they are not state agencies) and their arrangements of cooperation or engagement with each other are outside the scope of the inquiry. Of more interest is the program design and the interaction of the state with these external research providers, bilaterally or jointly. In that respect, the Commission finds that despite a number of announcements of good intentions in this respect, there has been little progress or impact.

Several factors mediate the impact of policy on performance, including the state's demography and policy regimes in other fields, including data privacy, and infrastructure (within the research sector, which is directly a matter of research policy, but also complementary infrastructure and amenities).

In summary, the Commission has in general not yet been able to establish significant contributions from South Australian research policy to performance of the R&D system.

The Commission considers that current and past management of the policy portfolio reduces the likelihood that it can contribute significantly to performance. This is because of the lack of a purposeful framework for policy design (purpose, tools and principles), lack of data on actions, lack of monitoring of outcomes and lack of performance evaluation. The Commission will further explore the importance of these factors.

A churn in policy is also evident, with a series of rediscovered 'new things' and new points of focus. Programs tend to have been abandoned and replaced by more current or topical approaches, rather than being appraised and then formally being shut down as a result of explicit decisions about their end-of-life.

The Commission concludes that while the state government is active, not many programs are long-lived, and there appears to be a pattern of recycling of policies that suggests there has been limited evaluation of initiatives.

The Commission is also concerned that, in terms of principles, policy is generally too tightly targeted to users of new technology or the technologies themselves. Accordingly, policy choices do not seem sufficiently contested in terms of participation by different research providers, nomination of specific providers and the limited extent of activities (especially funding) that are open to competition. On the latter point, activities provided 'in-kind' tend to be more open.

The Commission considers that given the nature and pace of technological change, a more customised, open and contested regime would add value. Such a regime can be organised in a way that is consistent with the principle of taking a longer-term view both of policy goals and the operation of programs (while not forgetting the value of 'sunset' clauses).

## 7.2 Path to performance

### 7.2.1 Principles for R&D policy development

The Commission has concluded that successive state governments have, appropriately, supported a significant amount of R&D activity over many years and this activity could have been, and can be, more effective. While individual programs vary, the broad pattern is that R&D policy and activities generally lack specific quantitative objectives, are complex, duplicate each-other at times and are not regularly and credibly assessed. As a result, there is, in the Commission's view, an important, underused opportunity to learn from previous policies and activities, and a lack of focus on what matters.

The Commission was asked how to increase the output, productivity and translation of R&D activity in SA.

An obvious response to this question is to increase spending on R&D.

However, as noted above, the level of spending on R&D in SA is already relatively high. There are other priorities, in the Commission's view, to be considered.

In particular, there is scope to increase the contribution of the R&D activity already undertaken, by raising its efficiency in two aspects:

1. increasing the productivity of the initiatives undertaken, that is, the level of output compared to the inputs involved (or the technical efficiency of the R&D effort); and
2. reconsidering the allocation of funds across projects and fields to yield a higher return (or the allocative efficiency of the R&D effort).

The application of principles with respect to the design of policy, including simplicity, accountability and transparency, will contribute to both forms of efficiency, for example by better assessments of performance of particular projects, leading to lessons learned for future investments and project designs.

The Commission has also noted that a significant portion of SA Government expenditure for R&D remains uncontested. That is, the state either allocates funding to itself to conduct R&D on behalf of industry and the community, or it provides funding directly to particular entities or projects for a predetermined purpose. Very little of this funding is genuinely contested in the market. This limits the extent to which state R&D funding can respond to the impulse of economic activity, and in turn, the extent to which the benefits of new knowledge and technologies can proliferate through the economy. Competitive arrangements allow greater scope for new research partnerships to emerge. The Commission's view is that given the nature of technological change, a greater weighting towards openness and contestability is likely to add value.

Given the lags discussed above, as state government considers its research spending, it pays to take a long view, in order to avoid ceasing to invest too soon. However, implementation of that approach demands some care to avoid prolonging an unproductive activity. Managing these risks is an inherent requirement of R&D policy.

A balance between these risks can be found, for example, via the establishment of gateways, identified in advance, at which decisions can be made to 'go or not go' further. Clearly, taking a long-term view creates some exposure to risk, which can be managed by developing a diversified research portfolio and sharing risk with other institutions, including research providers.

The local research system will perform better through cooperation, especially international collaboration. Examples noted above include the cooperation of local researchers with those in other locations, particularly international centres of excellence. Another example is cooperation with Australian Government agencies. Both channels provide important opportunities to add value to expenditure by the state government and local institutions. The Commission proposes that the research system performance indicators continue to include items related to collaboration. An explicit strategy for continuing to engage with Commonwealth agencies would also be valuable.

In summary, contributors to the efficiency of the local R&D system involve the application of principles of simplicity, accountability and transparency, as well as contestability and collaboration, plus the adoption of a longer time horizon in the context of relevant risk management systems.

These observations apply not only to the parts of the local R&D system for which the state government is accountable and to its policies and programs; they also apply to the state's research institutions that are independent of government. That said, the Commission's terms of reference limit it to making recommendations to the South Australian Government.

Pursuit of this approach to efficiency gains by the government will, in the Commission's view, be better supported by changes to its own R&D system architecture. (By architecture, the Commission refers to the institutions, roles and accountabilities of those involved in shaping, implementing and doing research and supporting those activities.)

Critical to success is the elevation of decision-making to provide a view across projects and to permit benchmarking of research performance. Decision-making at a higher level facilitates coordination and consistency among agencies and programs and the application of a framework of decision-making for investment across fields of research.

### 7.2.2 Proposed actions

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. In doing so, the Commission is to have particular regard to the SA Government's Growth State initiative, the work of the SA Chief Scientist, and role of the Department of Innovation and Skills.

The Commission concludes that critical opportunities exist to improve R&D policy and that efforts by the SA government can be made more effective across several domains.

#### *Options for a better R&D architecture*

A critical missing link in SA's R&D policy framework is strategic leadership — ensuring that the different elements of policy work together to deliver on their intended outcome. Indeed, there is no shortage of policies and programs, implemented across SA and through Commonwealth 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. Additionally, strategic decision-making on R&D policy is piecemeal, partly led by the Department of Innovation and Skills (with advice from the SA Chief Scientist). However, most R&D funding, capability and infrastructure resides in other agencies, most notably through PIRSA and SARDI, in the complex institutional arrangements of HMR, and in Renewal SA and the various governance structures that oversee the state's precincts.

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 considers that elevating and consolidating strategic decision-making within the architecture of government would go a long way to sharpening the efficacy of SA R&D policy. There are several possible architectures. The Commission sets out three approaches for discussion as part of moving to the recommendations in its final report. These options are intended to assist in identifying all the issues that need to be addressed in settling on a more robust, strategically framed and accountable whole-of-government approach to the state's R&D activities to lift their productivity.

The Commission is not proposing any specific option as the best way forward at this point.

Option 1: Minister responsible for R&D strategy and performance

This approach would have a Minister accountable for the state's R&D strategy. This would establish R&D targets that are simple and quantitative, noting that this draft report has identified some areas where targets could be set. R&D would be backed up by a team to support the achievement of targets, simplifying the governance arrangements and removing duplication now in government R&D policy, activity governance and administration. This work would be underpinned by consolidated information on the amount, location and performance of SA R&D activity.

The idea of a Minister for R&D has precedent in Australia. The Commission notes that NSW has a Minister for Health and Medical Research.

The Commission also notes there is currently a Minister for Innovation that is responsible for workforce training and skills, innovation and entrepreneurship, science and information economy, apprenticeships and traineeships, creative industries and skilled migration. These responsibilities clearly have strong links to R&D. Option 1 contemplates a complementary relationship focused on R&D as the engine room for innovation.

Option 2: An independent advisory body

This option contemplates a special purpose expert, independent advisory body to advise on the state's overall R&D strategy and performance. This would need to take into account current advisory roles like that of the Premier's Science and Innovation Council, but its intended scope would be broader. It would provide advice to government, among other matters, on improving the allocative efficiency of research resources, applying a distributed approach with a common framework. It would also provide public reporting on technical efficiency matters. To be effective it would need the same consolidated information identified in Option 1 and to be supported by a team.

Option 3: A strategic R&D committee of senior officials

This option would bring together, at a minimum, the most senior government officials who are accountable for R&D and R&D policy, including the SA Chief Scientist, and the key R&D executives in government. It could provide similar advice as in option 2 and be tasked with developing a whole of government R&D strategy, along with transparent accountability for performance (including targets and measures) in their own areas.

The same consolidated information as in Options 1 and 2 would be essential to underpin Option 3.

The Commission notes that the three options are not incompatible, and a better option might combine elements of all three.

The Commission concludes with three key elements that it considers essential to be incorporated in the management of all these options, or any feasible alternative that is identified during consultation.

Independent review of performance

The implementation of all options will depend not only on the adoption of a set of performance measures for the research system, but also on the consistent collection of data to track those measures across all agencies and research system participants. There would be annual measurement and reporting of SA performance against targets, by an independent group. This information would also include an accurate register of research assets.

Regular consideration of opportunity costs

While the opportunity remains in every year in the state budget process to argue for greater funding to allow delivery of the targets, the overall process would be driven by an innovative philosophy to R&D policy to seek savings and efficiencies (e.g. pursuing cheap and flexible virtual precincts rather than costly physical precincts) as well as having expectations of research excellence. These savings can then be applied to more productive use. In effect, there is continuing cost-benefit analysis of current activities against a range of policy targets and options.

A focus on people

The Commission found that the presence of high-performing researchers is necessary for high-quality R&D, more so than buildings, governance committees or administrators. The Commission proposes that attention shifts at the most senior levels of government towards a focus on researchers and their performance.

# Appendices

## Appendix 1: Submissions 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 2: Australian Government R&D policy

The Australian Government is a significant funder of R&D activity nationally. Table A2.1 shows the split of Australian Government investment in R&D across policy areas. 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).

*Table A2.1: Australian Government investment in R&D by program, by sector,* 2019-20

| Program | $m |
|---|---|
| **Investment in intramural R&D** | |
| **Australian Government research activities** | |
| CSIRO | 834 |
| Defence Science and Technology (DST) Group | 468 |
| Australian Government (Other R&D) | 790 |
| ***Sub-total*** | ***2,097*** |
| **Investment in extramural R&D** | |
| **Business enterprise sector** | |
| Industry R&D tax measures | 2012 |
| Business (other R&D) | 51 |
| ***Sub-total*** | ***2,063*** |
| **Higher education sector** | |
| Australian Research Council (ARC) | 791 |
| NHMRC (university) | 647 |
| Research block grants | 1,938 |
| Higher education (other R&D) | 237 |
| ***Sub-total*** | ***3,614*** |
| **Multisector** | |
| NHMRC (government, MRI, hospital, other) | 221 |
| Other health | 519 |
| Cooperative Research Centres (CRCs) | 184 |
| Rural R&D corporations | 342 |
| Other rural R&D | 31 |
| Energy and the environment | 286 |
| Other R&D | 255 |
| ***Sub-total*** | ***1,839*** |
| **Private Non-profit sector** | 10 |
| **Rest of the world** | 12 |
| **Total R&D investment** | ***9,636*** |

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

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.

The following sections outline the Australian Government's main R&D policies and their relevance to South Australia. While the Australian Government delivers a wide range of R&D-related initiatives, R&D policy outside of the university sector principally relies on three pillars: indirect business assistance through the Research and Development (R&D) Tax Incentive, direct assistance to entities through competitive grant programs, and the direct provision of services by public R&D institutions.

## A2.1 R&D Tax Incentive

The R&D Tax Incentive is the Australian government's preferred policy instrument to increase business investment in R&D. The tax incentive encourages business investment in R&D by providing tax offsets for eligible R&D expenditure.

Eligible companies with a turnover of less than $20 million receive a refundable tax offset, allowing the benefit to be paid as a cash refund if they are in a tax loss position. All other eligible companies receive a non-refundable tax offset to help reduce the tax they pay.

The 2016 review of the R&D Tax Incentive found that the program was falling short of its stated objectives, and in particular was not achieving the economic impacts of additionally and spillovers[112]. In response, the Australian Government announced it would amend the R&D Tax Incentive to better target it 'towards additional R&D activities, and improve the fiscal sustainability, integrity and administration of the program'[113]. The *Treasury Laws Amendment (Research and Development Tax Incentive) Bill 2019* is currently before the Senate. Detail on the current and proposed provisions are summarised in Table 2.2, below.

Overall, the proposed changes will make the R&D Tax Incentive less valuable to many entities. Some participants to this inquiry have expressed concern about the impact for South Australian businesses. For example, PWC made the point that businesses in capital intensive industries, such as manufacturing, may be less likely to qualify for the research intensity-based R&D tax offset for large R&D entities. Other participants highlighted that, irrespective of the reforms, the complexity and lack of consistency in the application of the rules creates uncertainty in making R&D investment decisions, which is especially detrimental for small businesses. The Australian Small Business and Family Enterprise Ombudsman (ASBFEO) raised these same concerns in her 2019 review report on the R&D Tax Incentive[114] and in the ASBFEO's recent submission on the R&D tax incentive Bill.

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[112] Bill Ferris, Alan Finkle & John Fraser, *Review of the R&D Tax Incentive* (2016).
[113] Parliament of the Commonwealth of Australia, *Treasury Laws Amendment (Research and Development Tax Incentive) Bill 2019*, Explanatory Memorandum (2019), 51, <https://parlinfo.aph.gov.au/parlInfo/download/legislation/ems/r6473_ems_a861d314-41c0-489b-b96e-875db0d25b75/upload_pdf/723652.pdf;fileType=application%2Fpdf>
[114] Australian Small Business and Family Enterprise Ombudsman, *Review of the R&D Tax Incentive* (Commonwealth of Australia, 2019).

*Table A2.2*: *Summary of current and proposed R&D tax incentive provisions*

| Existing provisions | Proposed changes |
|---|---|
| **Expenditure threshold** | |
| The R&D expenditure threshold is currently $100 million and has a legislated sunset date of 1 July 2024. | The R&D expenditure threshold will be increased to $150 million and will be made permanent in the law. This is the threshold at which tax relief reduces from the higher concessional rate to the relevant corporate tax rate. |
| **R&D Tax offset for small R&D entities (aggregated turnover of less than $20 million)** | |
| The R&D tax offset amount for small R&D entities is generally 43.5% | The R&D tax offset rate for small R&D entities will be their corporate tax rate (27.5% in 2019-20 for base rate entities) plus 13.5%. |
| The R&D tax offset amount is fully refundable for small R&D entities — they are entitled to a full refund for any R&D tax offset they receive in excess of their income tax liability. | The amount of R&D tax offset refund will be capped at $4 million per annum.<br>Clinical trials will not count towards the cap and will continue to be fully refundable (subject to the $150 million expenditure threshold). |
| **R&D Tax Offset for large R&D entities (aggregated turnover of $20 million or more)** | |
| The R&D tax offset rate for large R&D entities is 38.5% and is non-refundable. | The R&D tax offset rate for large R&D entities will be their corporate tax rate (30%) plus a premium based on their incremental R&D intensity.<br>Broadly, the premium will be calculated with reference to the percentage of total expenditure a company spends on R&D. |

*Source: Department of Parliamentary Services, Tax Laws Amendment (Research and Development Tax Incentive) Bill 2019, (Parliament of Australia, 2020).*

## A2.2 R&D institutions

The Australian Government also delivers R&D through its own research institutions. The following institutions have a significant presence in South Australia.

### *CSIRO*

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) operates under the provisions of the *Science and Industry Research Act 1949* which include:

- carrying out scientific research for any of the following purposes:
  - assisting Australian industry;
  - furthering the interests of the Australian community;
  - contributing to the achievement of Australian national objectives or the performance of the national and international responsibilities of the Commonwealth; and
  - any other purpose determined by the Minister;
- to encourage or facilitate the application or use of the results of such research.

An example of one of CSIRO's R&D programs for SMEs, Innovation Connections, is provided in box A2.1. CSIRO's secondary functions include international scientific liaison, training research workers, publishing research results, transferring technology from research, providing scientific services and disseminating information about science and technology.

*Box A2.1 Innovation Connections*

Innovation Connections is delivered by CSIRO and funded by the Australian Department of Industry, Science, Energy and Resources. The service helps SMEs understand their research needs, find the right expertise in the research sector, and fund collaborative research projects. Businesses can also access grants of up to $50,000 to support collaborative research projects. CSIRO facilitators work with businesses to identify business opportunities in both critical and strategic research, such as in new markets, materials and testing. CSIRO then finds the best scientists, engineers or technologies from across the research sector to make recommendations on how best to proceed.

Innovation Connections projects are for 2-12 months in duration, and businesses are required to make a cash contribution that matches the value of the grant. Grants can be accessed at any time and are based on eligibility. Each SME can access up to two Researcher Placements or Business Researcher Placement grants, as well as one Graduate Placement grant:

- **Researcher Placement:** placement of a researcher in the business to work collaboratively on a project to develop and implement a new idea with commercial potential (up to a maximum of $50,000).
- **Business Researcher Placement:** placement of a business' own research employee into a publicly funded research organisation, including CSIRO or an Australian university, to work collaboratively on a project and/or access specialised equipment and research infrastructure (up to a maximum of $50,000).
- **Graduate Placement:** employment of a graduate or postgraduate in a business to undertake a research project for 6-12 months (up to a maximum of $30,000).

*Source: Innovation Connections, CSIRO (Web Page, August 2020) <https://www.csiro.au/en/Do-business/Solutions-for-SMEs/Our-Funding-programs/Innovation-connections>*

In 2019, CSIRO entered into a Strategic Relationship Agreement (SRA) with the SA Minister for Industry and Skills, formalising a commitment to work together on R&D initiatives of mutual interest. Key features of the strategic relationship include:

(i) commitment to an investment in building capability in South Australia and nationally that increases current CSIRO staffing levels in SA and nationally, is complementary to its current national footprint and is aligned to the priority focus areas…;

(ii) investment in improving, up-scaling or developing new facilities to support local, state and national imperatives;

(iii) investment in supporting and developing new industries, expanding existing industries and encouraging job creation and economic growth in South Australia and nationally; and

(iv) encouraging collaboration with the South Australian research sector, which includes (but is not limited to), universities, research institutes, industry and state government agencies[115].

Parties have agreed on eight primary focus areas — space, defence, health, energy and resources, agriculture, food and wine, advanced manufacturing, and data and digital and innovation.

The SRA also establishes a steering committee to agree and give oversight to joint projects, with the South Australian Chief Scientist and Chief Entrepreneur sitting on this committee. As the SRA is not tied to any specific funding, any resourcing allocated to projects is provided at the discretion of the parties.

Separate to the SRA, CSIRO has advised the SAPC that it has recently appointed a senior executive responsible for its work in South Australia (currently, CSIRO Chief Scientist, Dr Cathy Foley).

### *Defence Science and Technology (DST) Group*

Defence Science and Technology (DST) Group is part of Australia's Department of Defence. DST is the Australian Government's lead agency responsible for applying science and technology to safeguard Australia's national interests. It has a presence in most Australian states and territories, including SA. It works closely with industry, universities and the scientific community.

DST Group has a significant R&D presence in SA. Its largest Australian operation is located at the Edinburgh facility in Adelaide, which is home to more than 1,200 highly skilled scientists, engineers, IT specialists and support staff undertaking military research in areas such as surveillance systems, autonomous systems, electronic warfare, information systems, propulsion and energy, weapons effects, human science and operations analysis[116]. DST Groups' research priorities are articulated through the STaR Shots initiative[117]. It also has an active 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[118].

### *Rural Research and Development Corporations*

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[119]. RDCs play a national role in supporting research in primary industries,

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[115] CSIRO & the Minister for Industry and Skills, Strategic Relationship Agreement (2019), 5-6.
[116] Defence SA, Defence Science and Technology, (Web page, undated) <https://www.defencesa.com/domains/research/defence-science-and-technology>
[117] Department of Defence, Strategy: Science, Technology and Research (STaR) Shots, ( 2020) <https://www.dst.defence.gov.au/strategy/defence-science-and-technology-strategy-2030/science-technology-and-research-star-shots>
[118] Department of Defence, Defence Research Collaboration Security Framework, ( 2020) <https://www.dst.defence.gov.au/partner-with-us/defence-research-collaboration-security-framework>
[119] Department of Agriculture, Water and the Environment, 'Rural Research and Development Corporations', (February 2020) <https://www.agriculture.gov.au/ag-farm-food/innovation/research_and_development_corporations_and_companies>

including working with universities, other research institutions and businesses, in addition to sector marketing activities.

Wine Australia is a statutory RDC with a significant presence in South Australia, as its head office is located in Adelaide. Its role is to coordinate and fund grape and wine research as well as development, and facilitate the dissemination, adoption and commercialisation of results. In 2018-19, it spent $23 million on its research, development and extension priorities nationally. The Fisheries Research and Development Corporation and the Grains Research and Development Corporation are also statutory RDCs with offices in South Australia.

At the end of 2019, the Department of Agriculture, Water and the Environment undertook public consultation on modernising the RDC system, but no outcomes from this process have been reported to date[120].

*Table A2.3: List of Commonwealth statutory and industry-owned rural RDCs and their Commonwealth funding for 2019-20 ($ million)*

| Commonwealth statutory rural RDCs | Industry-owned rural RDCs |
|---|---|
| • Wine Australia ($16m)<br>• Cotton Research and Development Corporation ($6m)<br>• Fisheries Research and Development Corporation ($23m)<br>• Grains Research and Development Corporation ($61m)<br>• Rural Industries Research and Development Corporation (AgriFutures) ($16m) | • Australian Egg Corporation Limited ($6m)<br>• Australian Livestock Export Corporation Limited (LiveCorp)[1]<br>• Australian Meat Processor Corporation ($10.8m)<br>• Australian Pork Limited ($6m)<br>• Australian Wool Innovation Limited ($18m)<br>• Dairy Australia Limited ($18.3m)<br>• Forest and Wood Products Australia ($6.5m)<br>• Horticulture Innovation Australia Limited ($54m)<br>• Meat and Livestock Australia ($81m)<br>• Sugar Research Australia Limited ($6m) |

*Sources: Department of Industry, Innovation and Science, 2019-20 Science, Research and Innovation (SRI) Budget Tables*

[1]*Funding for LiveCorp is not reported in the SRI Budget Tables.*

## A2.3 Competitive grant funding

The Australian Government provides direct assistance for R&D activities through a range of competitive grant programs. Much of this funding is directed towards the higher education sector (discussed in section 2.3) but it also benefits private and industry-led R&D entities. The Australian Government's major R&D grant schemes are outlined below. These grants programs are also discussed in more detail in Chapter 5 on R&D funding and expenditure.

### *National Competitive Grants Program*

The Australian Research Council (ARC) administers the National Competitive Grants Program (NCGP), which aims to support high quality fundamental and applied research and training through national competition. In 2018-19, the ARC administered $714 million though the NCGP.

[120] ibid.

The NCGP comprises two funding programs, *Discovery* and *Linkage*, and supports:[121]

- high-quality research leading to the discovery of new ideas and the advancement of knowledge;
- facilities and equipment that researchers need to be internationally competitive;
- researchers at different stages of their careers, including training and skills development of the next generation of researchers; and
- incentives for Australia's most talented researchers to work in partnership with leading researchers throughout the national innovation system and internationally, and to form alliances with Australian industry.

The *Discovery* program supports fundamental research for the development of new ideas, job creation, economic growth and enhanced quality of life in Australia. The Discovery schemes are: Australian Laureate Fellowships; Discovery Early Career Researcher Award; Discovery Indigenous; Discovery Projects; and Future Fellowships.

The *Linkage* program promotes national and international collaboration and research partnerships between key stakeholders in research and innovation, including higher education providers, government, business, industry and end-users. The Linkage schemes are: ARC Centres of Excellence; Industrial Transformation Research Program; Learned Academies Special Projects; Linkage Infrastructure, Equipment and Facilities; Linkage Projects; and Special Research Initiatives.

Since 2005, the largest programs nationally have been Discovery Projects (39 per cent of funding), Linkage Projects (14 per cent), ARC Centres of Excellence (12 per cent) and ARC Future Fellowships (11 per cent).

***Grants for health and medical research***

Although the subject of a separate Commission inquiry, it is important to recognise the prominence of health and medical research (HMR) in government policy. R&D for HMR remains a top priority for the Australian Government. In 2018-19, it spent $1.2 billion directly targeting HMR initiatives[122], representing around 8 per cent of total R&D expenditure. Central to this policy is the National Health and Medical Research Council (NHMRC), which is Australia's peak body for supporting HMR. In 2018-19, the NHMRC administered HMR grants totalling $846 million, making it the Australian Government's single largest R&D grant scheme. The Australian Government has also established the Medical Research Future Fund (MRFF)[123] — a $20 billion long-term fund that supports HMR to improves lives, build the economy and contribute to health system sustainability. South Australia's share of MRFF funding stands at 3.1 per cent, totalling $18.5 million for ten grants[124].

[121] Australia Research Council, National Competitive Grants Program, (2020), <https://www.arc.gov.au/grants/national-competitive-grants-program>
[122] This is the total of funding spent through NHMRC, the Medical Research Future Fund, and 'other health'. The true value of expenditure on health and medical research will be higher because this does not include funding from general R&D grants or university block funding that is allocated for health and medical research.
[123] The MRFF is included in 'Other Health' as a multi-sector R&D program in Table A 2.1.
[124] MRFF, Consolidated data as at Jan 31, 2020

***Cooperative Research Centres Program***

The Australian Government's Cooperative Research Centres (CRC) Program targets competitiveness and productivity by helping industry to partner with the research sector to solve industry-identified issues. The program provides long term funding for CRCs and funds short-term research collaborations through its CRC-Projects grants. To be eligible for funding, a CRC must include at least one business and one research organisation. The Commonwealth currently provides funding for 15 CRCs across the country[125]. Links to South Australia include:

- **SmartSat CRC** is a consortium of universities and research organisations, partnered with industry, and focused on developing know-how and technologies in advanced telecommunications and intelligent satellite systems. It was granted $55 million in CRC funding and is headquartered at Lot Fourteen.
- The **Innovative Manufacturing CRC** works with local manufacturers to promote the understanding and application of the Australian Government's Industry 4.0 agenda, including robotics and automation. It was granted $44 million in CRC funding and is located at the Tonsley Innovation District.
- The **Fight Food Waste CRC** looks at reducing food waste throughout the supply chain, transforming unavoidable waste into innovative high-value co-products, and engaging with industry and consumers to deliver behavioural change. It was granted $30 million following a successful bid led by the Department of Primary Industries and Regions (PIRSA)[126], although the program is national in scope. The Fight Food Waste CRC also receives funding through the South Australian Department of Industry, Innovation and Science, and has a presence at the Waite Institute, University of Adelaide.

The SA Government is leveraging on the Australian Government's CRC program through the Research, Commercialisation and Startup Fund, offering $2.4 million over three years to support CRCs headquartered or with a node located in SA[127].

***National Collaborative Research Infrastructure Strategy***

The National Collaborative Research Infrastructure Strategy[128] (NCRIS) is a national network of world class research infrastructure projects that support high quality research. It works with the research sector to identify priorities for research infrastructure and supports 40,000 domestic and international researchers each year. There are currently 23 funded NCRIS projects nationally, with only one being headquartered in South Australia — the Australia Plant Phenomics Facility at the Waite Research Institute, University of Adelaide. However, South Australian universities and researchers also participate in 11 NCRIS nodes led by interstate institutions.

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[125] Business.gov.au, Current Cooperative Research Centres, (July 2020) <www.business.gov.au/Grants-and-Programs/Cooperative-Research-Centres-CRC-Grants/Current-Cooperative-Research-Centres-CRCs>
[126] https://www.pir.sa.gov.au/food_and_wine/fight_food_waste_crc
[127] https://www.premier.sa.gov.au/news/media-releases/news/funding-to-support-industry-led-research-in-south-australia
[128] The NCRIS is included in 'Other R&D' as a multi-sector R&D program in Table A 2.1.

## A2.4 Industry levies

The Australian Government's rural RDCs are funded primarily through statutory R&D levies (or charges) on various commodities[129]. To expand Australia's rural R&D efforts, the Australian Government also matches the R&D component of the levies, in many cases (and within certain prescribed limits), on a dollar for dollar basis. Levies are initiated at the request of industry and are collected and administered by the Commonwealth Department of Agriculture, Water and the Environment, which it then distributes to the RDCs to undertake and fund R&D. In 2019-20, the Department collected an estimated $346 million in rural R&D research levies.

## A2.5 Intellectual property law

Intellectual property (IP) and other intangible assets that relate to doing business include patents, trademarks, designs, and secret processes and formulae.

Australian IP law is designed to encourage innovation and protect businesses that develop original IP to have a competitive advantage. Australia is also a signatory to a number of international agreements that protect IP in other countries. States and territories have policies relating to their own IP and rules for contracting with businesses in relation to IP.

The South Australian Government also has an Intellectual Property (IP) Policy that applies to IP generated, acquired or held by agencies on behalf of government. Its purpose is to:

- provide a framework for the use, generation, acquisition and management of IP in government; and
- ensure that government-owned intellectual property is used to generate public value, knowledge transfer and innovation to the fullest extent possible.

## A2.6 Regulation of Australian universities

The Tertiary Education Quality and Standards Agency (TEQSA) is Australia's single national quality assurance and regulatory agency for higher education. The standards that are applied are set out in the Higher Education Standards Framework (Threshold Standards) 2015 (the HES Framework). The HES specifically reference the minimum requirements for the conduct of research and recording of research activity by a higher education provider; and additional requirements that must be met if research training is offered.

Higher education providers receiving funding from national Australian funding bodies, such as the Australian Research Council (ARC) or the National Health and Medical Research Council (NHMRC) or other major agencies, must meet stringent requirements. including various codes of conduct, attached to their funding that are more detailed than the requirements of the HES Framework.

The Australian Qualifications Framework is the national policy which specifies the nature of qualifications in the education and training sector. This includes postgraduate research degrees, which are important elements of research activity.

[129] Department of Agriculture, Water and the Environment 'Rural Research and Development Corporations', (February 2020) <https://www.agriculture.gov.au/ag-farm-food/innovation/research_and_development_corporations_and_companies>

# Appendix 3: R&D policies in international jurisdictions

## A3.1 Introduction

The terms of reference for this inquiry requires the Commission to recommend actions that the South Australian Government might 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 doing so, increase the state's share of Australian Government funding for research and rate of economic growth.

The purpose of this appendix is to consider policies in overseas jurisdictions which present lessons for South Australia. The Commission has reviewed literature for commonly cited 'best performing' nations and sub-national regions in R&D and examined what common elements are shared among them as well as to identify policies which can aim to address areas where South Australia's performance can be improved.

While national governments typically have a different set of policy levers available to them than sub-national governments, the Commission has still examined a few leaders to identify possible policies that are missing in South Australia, or that could be improved.

Not all these regions will be directly comparable to South Australia for various reasons such as having significantly larger economies, being more closely located to global trade routes or having vastly different industry structures.

The Commission has not made a judgement on the policies of each jurisdiction. Nor has the Commission made a judgement on which jurisdictions are best performing. Rather, the jurisdictions listed here are commonly cited in the policy documents, reviews and economic literature that the Commission has reviewed.

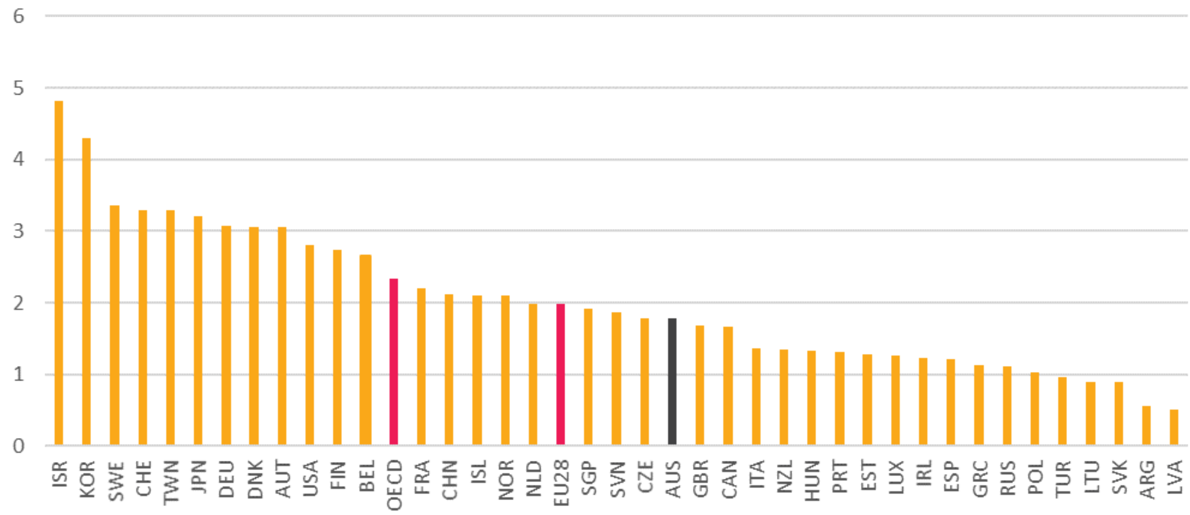
## A3.2 Best performing jurisdictions

Data on R&D activity and outcomes are often available only at the national level, which makes it easier to identify high performing nations rather than sub-national regions. As a result, it is the countries discussed in section A3.2.1 have been largely identified through OECD data as well as through stakeholder views in consultation, whereas the regions identified in section A3.2.2 have largely been identified through stakeholder views and reviews of previous literature.

### *A3.2.1 National*

Total expenditure on R&D as a per cent of Gross Domestic Product (GDP) is presented in Figure A3.1.

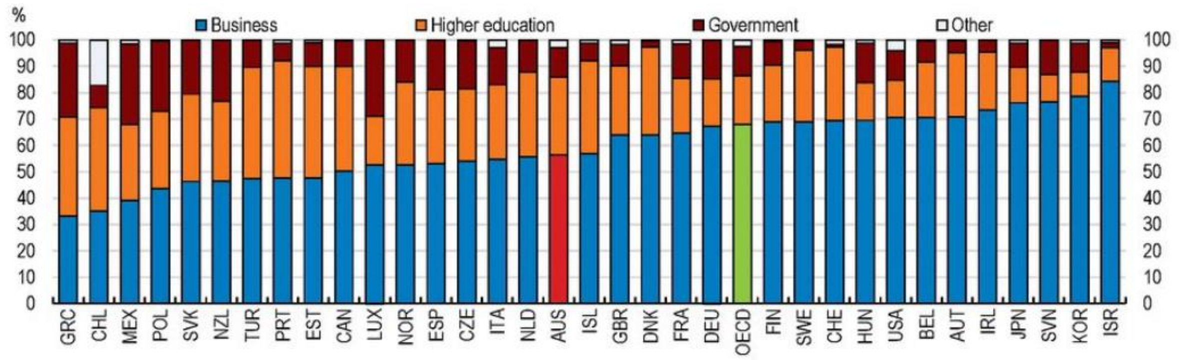
*Figure A3.1: Total expenditure on R&D as a per cent of GDP, OECD countries, 2017*




*Source: OECD Main Science and Technology Indicators (database)*

Australia has the 14th highest total expenditure on R&D as a percentage of GDP in the OECD, which is slightly less than the OECD average. The countries with the highest levels of expenditure include Republic of Korea, Israel and Japan. These top spending countries mainly achieve these high levels of expenditure through high business expenditure on R&D, rather than higher education and government expenditure.

*Figure A3.2: R&D expenditure by performing sector, OECD countries, 2013 or latest*




*Source: OECD Main Science and Technology Indicators (database)*

<u>South Korea</u>

South Korea's success in R&D is an example of a top-down approach to developing a domestic R&D intensive industry with close collaboration between government, industry and academia. The South Korean Government, in seeking to reduce its reliance on technology imports and the construction of industrial facilities by foreign companies, sought to develop key domestic industries. Strong government support for R&D was a key part of this strategy.

South Korea has the second highest total expenditure on R&D in the world, as shown in Figure A3.1, with almost three quarters of this expenditure performed by business and 88 per cent of this in manufacturing.[130] South Korea also had the greatest share of researchers who moved from industry to academia between 2017 and 2019[131].

The South Korean government also provides significant incentives to attract global headquarters and R&D centres to locate in Korea in order to attract high value-added foreign investment.[132] These incentives include income tax reductions for foreign workers

Israel

Israel's research and development system is primarily based on strong links between its military and business environment. Supply side support for military R&D programs created commercial specialisations in cyber-security, IT and smart infrastructure. These specialisations helped attract major domestic and foreign business R&D and venture capital.

Singapore

Singapore focusses its manufacturing effort on high quality infrastructure and specialised international talent in a small number of innovative industries. The Government enables this through significant tax relief, infrastructure support, training subsidies and attracting international talent to its universities and major innovation parks. As a result, Singapore has been able to achieve high levels of business R&D expenditure in life sciences, materials, clean technology and digital media.

Finland

Finland's success in R&D follows a different strategy than the above-mentioned manufacturing and technology focussed countries. Finland invests heavily in the fundamentals of school education, science and technology, with the country consistently ranking highly in most metrics of educational system performance such as the Programme for International Student Assessment (PISA). The country also invests heavily in innovation funds (such as Business Finland) and mechanisms to boost business and academic collaboration. Finland is recognised as having world-class capability in user-centred design, advanced health care services, food and nutrition, and energy conservation[133].

### *A3.2.2 Sub-national*

California

California is widely recognised as one of the best performing sub-national regions in private sector R&D activity, as the leading U.S. state in both industry R&D expenditure and the number of patents. While Silicon Valley provides a great example of the economic value of knowledge sharing, California has numerous innovation clusters with six metropolitan areas that rank among the top 20 technology centres in the U.S. and Canada[134]. While California ranks first in per capita private sector R&D expenditure, it ranks 17th in per capita academic R&D expenditure.

[130] Korea-EU Research Centre, 'Korea R&D Policy and Programs' (2020), <https://k-erc.eu/for-european-researchers/korea-rd-policy-and-programmes/>
[131] L Dayton, ;How South Korea made itself a global innovation leader' (2020), *Nature*, <https://www.nature.com/articles/d41586-020-01466-7>
[132] Invest Korea, R&D Incentives, (2020) <http://m.investkorea.org/en/innovation/incentive.do>
[133] NSW Innovation and Productivity Council, *The Innovation Economy* (2018), 33
[134] Milken Institute, 'Milken Institute Report Suggests Solutions to Maintain California's Innovation Economy—Including Doubling the R&D Tax Credit for Firms' (2019), Press Release.

The state's technology and R&D reputation was built in the sectors of defence, aerospace, computing and early-stage electronics with much of this expertise built on publicly funded research at United States (US) government laboratories and California's public and private universities.

The state is also the largest recipient of venture capital funding in the U.S., receiving $28.1 billion in 2014[135].

California also has a high proportion of workers with STEM qualifications and has nine STEM fields where its intensity ranks among the top seven states[136].

The state currently incentivises industry R&D mainly through a research tax credit of 15 per cent of qualifying supplemental research activity conducted within the state. This is in addition to a federal tax credit.

<u>Massachusetts</u>

Massachusetts is recognised as the most R&D intensive region in the world, investing over five per cent of GSP in R&D[137].

Unlike California, Massachusetts' reputation on R&D is based on the strength of its universities, with universities such as the Massachusetts Institute of Technology (MIT) long being recognised as world leaders in innovative research.

Along with a strong university sector, the state invests heavily in innovation through legislative or gubernatorial mandates or through a dedicated agency for the innovation economy, the Massachusetts Technology Collaborative.

The state government has invested heavily in infrastructure to support R&D, including the creation of the Massachusetts Life Sciences Centre in 2006, the Massachusetts Clean Energy Centre in 2008 and the Massachusetts Big Data Initiative.

The state has also increasingly sought to link state level research and policy with the federal level. In 2016, the state established a collaborative business portal, called the Massachusetts Innovation Bridge, in partnership between the state and a non-profit corporation that operates federally sponsored R&D centres. The aim of the partnership is to allow federal agencies to create new relationships with innovative academic institutions, Massachusetts-based companies and companies that have not previously worked with the federal government.

<u>Bangalore</u>

The Indian state of Karnataka is widely recognised as having a successful R&D ecosystem in Bangalore, based on the presence of significant government, industry and academic research institutes with interactions between them. The state fostered this ecosystem through incentives to attract global information technology (IT) and biotechnology firms to relocate to Bangalore and invested heavily in software technology parks. The demand and competition for talent from these firms resulted in investments in training programs, and sponsored research degrees for locals which supported the growth in R&D.

[135] Milken Institute, *California's Innovation-Based Economy: Policies to Maintain and Enhance It* (2019), 4
[136] Ibid.
[137] NSW Innovation and Productivity Council, *The Innovation Economy* (2018), 42.

Bavaria

Bavaria is another region with high levels of business expenditure on R&D (2.2 per cent of GSP in 2007, more than double that of South Australia)[138]. Bavaria's patents intensity also far exceeds the European average with 444.9 per million population in 2006 compared to the European average of 115.1.

Bavaria's strengths in R&D are primarily due to the presence of a large number of multinational corporations such as Siemens, Roche and General Electric locating their activity in Munich. As a result, business expenditure makes up almost 80 per cent of total R&D investment in the region. However, while Bavaria's BERD far exceeds the national and European average, its government expenditure on R&D is below the national average (although roughly equal to the European average) and its HERD is less than both.

Bavaria hosts many public research institutes and headquarters of public research organisations such as the Max Planck Society and the Fraunhofer Society, which are based in Munich.

The Bavarian government primarily supports R&D through its support for innovation networks and clusters, through the Bavarian Cluster Initiative. The main objective of the cluster initiative is to promote networking among Bavaria's SMEs and focus on technology fields surrounding the five themes of: mobility; materials engineering; life sciences and environment; information technology and electronics; and financial services and media.

The Bavarian Government also invests in R&D through investing in the creation of new university places, providing risk capital and support of young technology-oriented enterprises and investing in infrastructure for applied research and technology transfer (such as the creation and support of the Fraunhofer institutes).

## A3.3 R&D policies

This section presents a summary of the types of policies that international jurisdictions use to support R&D. These policies have been summarised into the four themes of: boosting private sector R&D; supporting higher education R&D; R&D workforce policies; and enhancing collaboration.

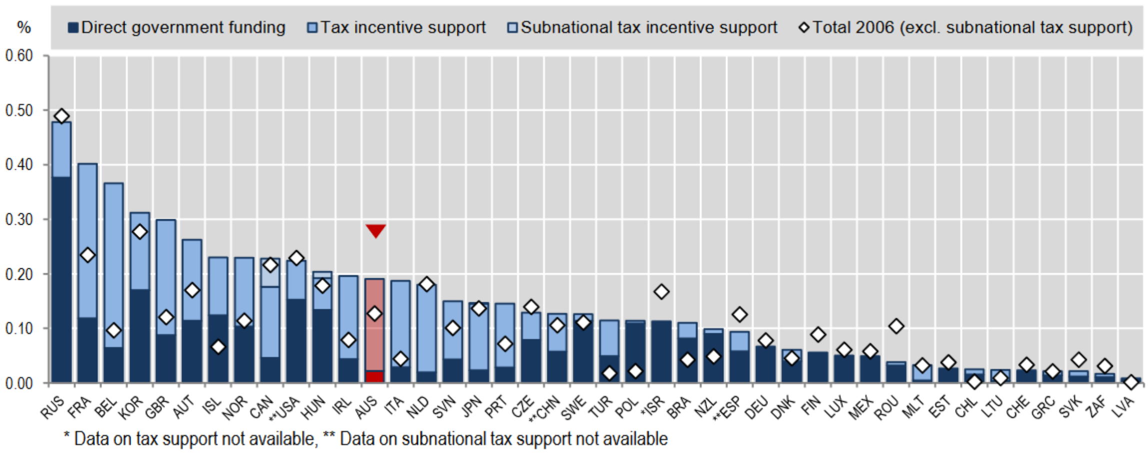
The policies listed below, while not exhaustive, canvas the range of policies adopted by highly performing regions. They are largely based on the regions identified in section A3.2 but are not limited to them.

### *A3.3.1 Boosting private sector R&D expenditure*

Most countries, including Australia, incentivise private sector R&D through a combination of tax incentives and direct support. In Australia, while total government support for R&D as a percentage of GDP is relatively high, direct government funding makes up a much smaller proportion of total government support for private sector R&D than most other OECD countries.

[138] Baier, E., Regional Innovation Monitor: Regional Innovation Report (Bavaria), (2012)

*Figure A3.3: Direct government funding of business R&D and tax incentives for R&D as a per cent of GDP, 2017 or nearest year*




*Source*: OECD, R&D Tax Incentive Database, http://oe.cd/rdtax, December 2019.

At the sub-national level, governments mainly target increasing private sector R&D activity through the establishment and support of an ecosystem, possibly including 'innovation precincts' and technology parks with strong links between businesses and universities. Almost all regions the Commission has examined had some form of innovation precinct or technology park with the presence of private R&D active companies and at least one university or government R&D provider.

Other supports include specific programs to attract R&D active companies to locate in the region/state.

In some countries, such as Canada and Hungary, states or provinces also offer tax incentives for R&D. However, these countries tend to have different taxation arrangements than Australia where states do not charge corporate or income tax.

Other regions offer direct financial support to R&D active companies. This can take the form of either direct funding for research, such as through the Singapore SG Equity Fund or the Finnish Innovation fund, or through reducing risk for private venture capital in investing in local start-ups such as the Israeli government's venture capital fund Yozam.

Government procurement is also harnessed in some regions as a method of enabling research and development, with a particular view to commercialising outcomes. The Small Business Innovation Research Program (SBIR) in the USA is the most widely known program. Under the SBIR, companies are able to apply for grants to develop 'early stage innovation ideas' that are too risky for private capital to secure contracts. All recipient projects must have potential for commercialisation and meet specific US Government R&D needs. Other examples of procurement-based support for R&D include the UK Small business research initiative and Innovative Solutions Canada.

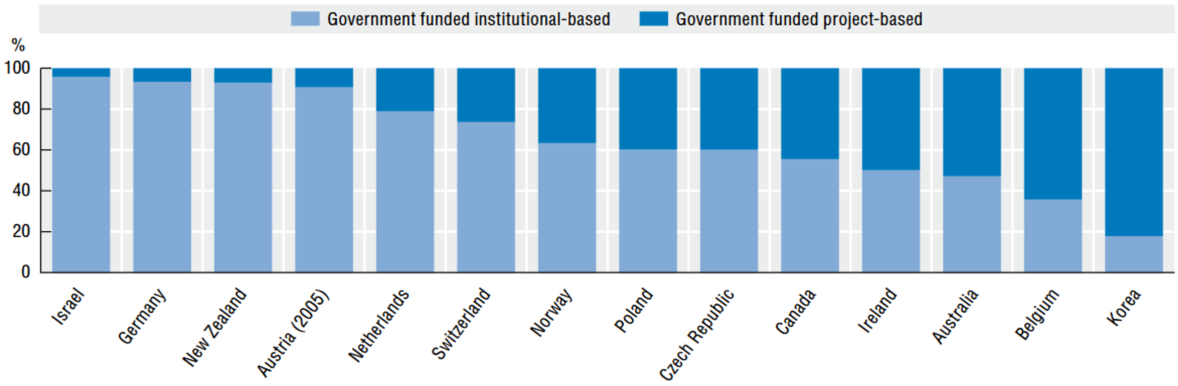
Governments also invest in infrastructure that can assist companies in undertaking R&D. This infrastructure can take the form of specialised equipment made available for use by private sector researchers as government research laboratories or innovation precincts or it can be simply investing in core infrastructure that is not specific to R&D but is needed for many businesses to thrive. One example of the latter is the Massachusetts Government's investment in a 1,200-mile fibre optic network to connect key research facilities in western and central Massachusetts.

### A3.3.2 Supporting higher education research and development

Universities are one of the main providers of basic research and so public support for higher education R&D is critical. While in Australia funding for universities is primarily a Commonwealth responsibility, in many countries such as the United States of America (USA), sub-national governments provide significant university funding.

Governments have two methods of direct R&D funding for higher education R&D, institutional and project-based funding. Institutional-based funding can support stable, long-term funding of research and project-based funding is able to promote research strengths in key areas of national interest, as well as increasing competition within the research system. The mix of funding types varies widely, with Israel adopting an almost entirely institutional-based funding approach and South Korea having over 80 per cent project-based.

*Figure A3.4: Government funded R&D in higher education, by type of funding, 2008*[139]




*Note:* This is an experimental indicator. International comparability is currently limited.
*Source:* OECD, based on preliminary data from the Microdata project on public R&D funding, 2009. See chapter notes.
StatLink http://dx.doi.org/10.1787/836005248761

### A3.3.3 R&D workforce policies

Many regions have policies that target long-term improvements in R&D and productivity through improving the quality of the workforce and their preparedness for work, both inside and outside of academia.

The Commission has heard that many stakeholders see European countries providing a strong model for reducing the pro-academia bias in research degrees and increasing the preparedness of PhD graduates for work outside of academia. These policies largely include options for industry-based placements, or coursework that supports graduates to apply their skills outside of academia. For instance, in the Netherlands nearly all universities offer entrepreneurship courses as part of their degrees.

Many countries also offer incentives to attract foreign talent to their universities, businesses and research centres. For instance, South Korea offer a range of support to attract global companies to establish their R&D centres in Korea, including a 50 per cent reduction in income tax for foreign technology experts for two years.

[139] OECD, *Measuring Innovation: A New Perspective*, (2010), Chapter 4.4, Investing in Innovation – Higher education and basic research, p. 83.

Countries also harness their skilled immigration system to favour highly skilled individuals in key areas. For instance, South Korea's 'Gold Card System enables skilled workers in key technology fields to be granted longer-term visas than they would otherwise be eligible for.

Expertise is also provided in many countries through business coaches or by seconding public sector experts. For example, Singapore seconds research scientists and engineers from national research institutions to provide technical expertise and strategic guidance to SMEs.

### *A3.3.4 Enhancing collaboration*

Innovation precincts

Government support for innovation precincts or technology parks appears to be the main policy instrument used by sub-national governments to foster links between government, academia and industry R&D.

The science park and innovation precinct model originated with the Stanford Research Park—in what is now Silicon Valley—and was then expanded to include the development of Research Triangle Park in Raleigh Durham, and later the innovation corridors outside Boston, Philadelphia, and Washington D.C. The original innovation districts were generally closed innovation systems in which firms and scientists carefully guarded their ideas, and where interactions between them were limited.[140] The types of innovation precincts can be categorised as:

- Anchor precincts – centred around a major institution such as a university, hospital or large corporation attracting a large base of firms supporting collaboration;
- Redeveloped urban areas – supporting existing inner-city areas to undergo change to become more innovation and accompanied by enhanced economic infrastructure; and
- Urbanised science parks – precincts in outer or suburban areas incorporating multiple uses and increasing density to overcome isolation or sprawling development.

The global breadth of research scope and diversity in precinct model operations, governance and remit has increased significantly since the early models. There are multiple different approaches used for establishing and developing innovation precincts globally. Some of the noteworthy features of perceived successful precincts are:

- The Medical and Related Sciences (MaRS) Discovery District in Toronto is based on collaboration between medical institutions participating through relocation of R&D functions and capabilities and increasing their interaction between research and entrepreneurship. The district is a non-profit corporation established in 2000 and acts as a partnership vehicle to engage multiple tiers of government, capital providers and industry to commercialise publicly funded medical research and other technologies.
- London's Tech City builds on the city's strengths in finance, IT, media, advertising, fashion, architecture, engineering and software. The precinct is promoted by local and national government, with the support of an investment promotion agency.

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

- Tel Aviv's main innovation precinct, Herzliya, is based on a culture of risk appetite, acceptance of failure and inter-generational mentorship. The precinct has sourced its labour and finance inputs from the region's military graduates, immigrant entrepreneurs and through the attraction of American venture capital funds.
- The Paris-Saclay suburban precinct was established through a government joint venture consolidating research institutions, academic institutions, and large firms within the site.

The Commission has examined several precincts in Australia. One of the more interesting examples is the CSIRO operated collaboration hub at Lindfield in NSW. The hub provides access to CSIRO research facilities and innovation services that concentrate on using collaboration to solve technical problems. The hub is also confined to the one sector and is for start-ups.

CSIRO Lindfield Collaboration Hub

The Lindfield Collaboration Hub is based in NSW and supported by the NSW Government's Boosting Business Innovation Program. The hub is based on CSIRO's Lindfield campus enabling early stage and established companies to move to the Hub and access CSIRO facilities, research expertise, business networks and commercialisation knowledge.

The hub is a community of technology start-ups (especially electronics) seeking access to equipment or expertise, introductions through CSIRO's substantial networks through to advice on specific technical questions. Companies are selected based on their future growth prospects and how co-location will benefit their business. The start-ups pay commercial rental for their tenancy.

Companies at the Lindfield site are assisted through the NSW Government's Boosting Innovation Grant (committed $1.5 million over 3 years). This supports a relationship between companies and researchers on the site. In terms of the site itself, companies have access to a wide range of resources – common areas, equipment and innovation spaces.

Other policies to enhance collaboration

The European examples are based on physical infrastructure whereas the US example is very much a system of research translation and collaboration, often with the backing of legislative instruments.

The examples below are therefore a description of the type of landscape usually at national rather than regional level. The lessons for South Australia are that a successful approach requires a formalisation and structure with a large degree of backing for a sustained period that is additive to the knowledge transfer and commercialisation functions of universities.

The challenge remains to determine where the gaps are and what are the sectors of focus required to ensure the truly additive nature of any reforms in the operation of such an approach. Translational infrastructure in these examples is geared towards connectivity of business, industry and government, not for a broad business purpose to grow and maintain a precinct based on place. Rather they are technology centres solely focused on commercialisation and translational outcomes.

Catapult Centres (United Kingdom)

The core rationale for establishing Catapult Centres in the United Kingdom (UK) was that physical centres with associated technical know-how generally operate in the middle levels of technology readiness and provide services that address market failures, which impact heavily on capital investment by firms and tend to pay off over longer timescales.

The centres were established to close the critical gap between research findings and their subsequent development into commercial propositions. Reform of previous arrangements made the case for long-term UK investment in a network of technology and innovation centres, based on best practice in other countries, to 'deliver a step change in the UK's ability to commercialise its research'.[141]

Reforms were implemented to provide business with access to the best technical expertise, infrastructure, skills and equipment to provide a new framework for long-term investment and collaboration between business and the UK research base, complementing the other programmes and resources available to stimulate innovation. This was done to:

- bridge the gap between research and commercialisation;
- foster collaboration within and between organisations and sectors;
- stimulate demand for innovation;
- get new ideas and technologies to market quicker;
- break down barriers to success; and
- help SMEs get ideas to market.

Fraunhofer institute (Germany)

The Fraunhofer Institute was founded in 1949 and currently operates 74 institutes and research institutions and includes 28,000 staff of qualified scientists and engineers.

The institute works with an annual research budget of 2.8 billion euros. Of this sum, 2.3 billion euros is generated through contract research. Around 70 per cent of Fraunhofer's contract research revenue is derived from contracts with industry and publicly funded research projects. The remaining 30 per cent comes from the German federal and state governments in the form of base funding. This enables the institutes to work on solutions to problems that are of importance for industry and society.

Interdisciplinary research teams work together with partners from industry and government in order to transform ideas into innovative technologies, to coordinate and realise key research projects with systematic relevance, and to strengthen the German and the European economy with a commitment to creating value.

The institute offers researchers the opportunity for independent, creative and, at the same time, targeted work. Fraunhofer Institutes provide PhD students with improved prospects in industry by virtue of practical training and early experience acquired dealing with contract partners.

TNO (Netherlands)

The role of Research and Technology Organizations (RTOs) in the Netherlands is to provide innovative products, services and processes. TNO (*English: Netherlands Organisation for Applied Scientific Research*) is an independent research organisation whose mission is the

[141] Dr Hermann Hauser (United Kingdom), *Review of the Catapult Network: Recommendations on the future shape, scope and ambitions of the programme*, Government Review (November 2014).

joint creation of economic and social value. The TNO network has 3,400 research professionals whose outputs create products, services and processes.

Every four years, in close collaboration with stakeholders, the organisation conceives a strategic plan that is their proposal to society. The strategy reflects the trends observed in society and technology with five domains defined for future focus. These domains are in line with the challenges and ambitions of the most important policy and social themes in the Netherlands and the rest of Europe.

<u>Other European examples</u>

Examples of how several OECD countries have supported the development of joint research laboratories and public-private partnerships for co-creation include the following:

- Collaborative laboratories (CoLAB) in Portugal, launched in 2018, are private, non-profit foundations or private companies that integrate activities of research units higher education institutions, public research laboratories, intermediate organisations, companies and business associations. With a high share of private funding (>50 per cent), they focus on performing market-driven research and providing professional R&D services to industry.
- The French LabCom programme was launched in 2013 to support the establishment of joint labs for universities, public research institutes and firms (with a focus on SMEs). Selected projects are awarded up to EUR 300 000 for a maximum duration of 36 months.
- The Austrian Christian Doppler Research Association (CDG) Laboratories are established based on an industry challenge (industry-relevant questions in basic research), receive 50 per cent of industry co-funding, and last no longer than seven years. The CDG programme represents a more flexible approach than the previous examples because it does not establish new legal entities, as CDG laboratories are hosted at universities.
- In Hungary, the Centres for Higher Education and Industrial Cooperation (FIEK) programme was launched in 2017 to encourage new organisational models for long-term university-industry links. The centres are established within the premises of universities as autonomous organisational units under the direct control of the sector to enhance their flexibility and reduce bureaucracy.

<u>Land Grants system</u>

The United States has operated a national system of land-grant colleges and universities over a long period of time that is recognised for its breadth, reach, and excellence in teaching, research, and extension for agriculture.

The system is founded in legislative instruments covering establishment, framework, participating institutions and funding. The *Morrill Acts (1862 and 1890)* and the *Equity in Educational Land-Grant Status Act 1994* established the institutions that participate in the land-grant system. The *Hatch Act 1887*, *Evans-Allen Act 1977* and provisions of the *Agricultural Research, Extension, and Education Reform Act 1998* provide the framework for funding research at land-grant institutions. The federal government provides funds, often with state matching requirements, to execute the system's three-fold mission of agricultural teaching, research and extension.

The United States Department of Agriculture's (USDA) National Institute of Food and Agriculture (NIFA) distributes funding to the states as capacity grants, on a formula basis as determined by statute, or to participating institutions on a competitive basis.

State Agricultural Experiment Stations (SAES) receive federal research capacity funds with a one-to-one non-federal matching requirement or they can receive federal research funds through competitive grants programs. There are also legislative provisions for agricultural extension funding in the system.

Land-grant institutions are in every U.S. state and many territories. These institutions educate future farmers and ranchers and form the mainstay of a national network of agricultural extension and experiment stations.

The land-grant university system operates the U.S. Cooperative Extension Service (CES) in partnership with federal, state, and local governments. The CES provides non-formal education to agricultural producers and communities through its network of offices located in most of the 3,000 U.S. counties and territories.

In terms of effectiveness, the funding model makes land grant institutions a preferred choice for academics enabling them to work across the value chain with better access to industry and funding. The system essentially provides exposure to the most pressing issues facing industry, along with the funding to do the work.

A federal committee was established to evaluate applications ensuring that the proposals were multi-disciplinary, tri-state, and addressed major issues. Post-project performance is reviewed by independent academics and is evaluated on impact and industry benefit with ongoing academic involvement based on testimonials from industry on applied research and outreach. Most projects would run over a long period, up to 15 years, with funding milestones structured over multiple year intervals.

Expectations of academic staff differ from what is observed in Australia. The academic roles have a service component, usually education delivery to producers such as seasonal outlook on prices, forecasting, farm management and potentially some post-farm gate activity. Further, there is the expectation that the research is peer reviewed and published in high impact journals.

<u>Other examples</u>

Other governments offer further incentives for businesses to collaborate with universities and government research centres for R&D. For example, Ontario offers a 20 per cent refundable tax credit on research performed under contract with eligible research institutes, including universities, hospitals and other government and non-profit research institutes.[142]

Other policies to enhance collaboration focus on removing barriers to mobility between research sectors. While there is a view that these barriers tend to be cultural in nature, there have been several attempts at incentivising movement between sectors. France's R&D tax credit for instance, counts wage expenditures of PhD researchers twice during the first 24 months following their recruitment.

[142] Canada, 'Ontario business-research institute tax credit' (2020), <https://www.canada.ca/en/revenue-agency/services/tax/businesses/topics/corporations/provincial-territorial-corporation-tax/ontario-provincial-corporation-tax/ontario-business-research-institute-tax-credit.html>

# Appendix 4: Regression results for BLADE Core analysis

*Table A4.1: Standard logistic regression results and marginal effects for Australian companies*

| Variables | Odds ratio | Coefficient | | SE[a] | Marginal effect | |
|---|---|---|---|---|---|---|
| **Having R&D Expenditure (Response Variable)** | | | | | | |
| | | | | | | |
| **Business size (Reference=1-19 employees)** | | | | | | |
| 20-99 employees | 2.3846 | 0.8690*** | | 0.0726 | 0.009 | *** |
| 100-199 employees | 3.4710 | 1.2444*** | | 0.2074 | 0.017 | *** |
| 200 or more employees | 4.4637 | 1.4960*** | | 0.2722 | 0.024 | *** |
| **Business location (Reference = South Australia)** | | | | | | |
| NSW | 0.8408 | -0.1734*** | | 0.0350 | -0.001 | *** |
| VIC | 0.9916 | -0.0084 | | 0.0422 | -0.00006 | |
| QLD | 0.9182 | -0.0853* | | 0.0408 | -0.001 | * |
| WA | 1.0850 | 0.0816* | | 0.0519 | 0.001 | * |
| TAS | 0.7610 | -0.2731*** | | 0.0696 | -0.002 | *** |
| NT | 0.2696 | -1.3107*** | | 0.0539 | -0.005 | *** |
| ACT | 0.6902 | -0.3708*** | | 0.0640 | -0.002 | *** |
| **Industry Division (Reference = Agriculture, Forestry and Fishing)** | | | | | | |
| Mining | 6.0986 | 1.8081*** | | 0.4832 | 0.034 | *** |
| Manufacturing | 3.0050 | 1.1003*** | | 0.1825 | 0.013 | *** |
| Electricity, Gas, Water and Waste Services | 2.1328 | 0.7574*** | | 0.2288 | 0.008 | *** |
| Construction | 0.2115 | -1.5535*** | | 0.0155 | -0.007 | *** |
| Wholesale Trade | 1.1144 | 0.1083* | | 0.0723 | 0.001 | * |
| Retail Trade | 0.4438 | -0.8123*** | | 0.0325 | -0.004 | *** |
| Accommodation and Food Services | 0.0805 | -2.5197*** | | 0.0113 | -0.007 | *** |
| Transport, Postal and Warehousing | 0.2404 | -1.4253*** | | 0.0235 | -0.006 | *** |
| Information, Media and Telecommunications | 3.3067 | 1.1960*** | | 0.2426 | 0.016 | *** |
| Financial and Insurance Services | 0.8690 | -0.1404** | | 0.0564 | -0.001 | ** |
| Rental, Hiring and Real Estate Services | 0.5480 | -0.6015*** | | 0.0396 | -0.003 | *** |
| Professional, Scientific and Technical Services | 2.5281 | 0.9275*** | | 0.1491 | 0.009 | *** |
| Administrative and Support Services | 0.5145 | -0.6645*** | | 0.0413 | -0.004 | *** |
| Public Administration and Safety | 0.6817 | -0.3831** | | 0.1081 | -0.002 | ** |
| Education and Training | 0.7048 | -0.3498*** | | 0.0750 | -0.002 | *** |
| Health Care and Social Assistance | 0.3952 | -0.9285*** | | 0.0338 | -0.004 | *** |
| Arts and Recreation Services | 0.5247 | -0.6450*** | | 0.0670 | -0.003 | *** |
| Other Services | 0.4047 | -0.9045*** | | 0.0361 | -0.004 | *** |
| Age of business | 0.9863 | -0.0138*** | | 0.0011 | -0.0001 | *** |
| Log of Income | 1.2995 | 0.2620*** | | 0.0092 | 0.002 | *** |
| Intercept | 0.0006 | -7.4422*** | | 0.0001 | | |
| Number of observations (n) | 858298 | | | | | |
| Pseudo R2 | 0.1645 | | | | | |
| Log Likelihood | -57520.56 | | | | | |

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

*(a) Robust standard error.*

*Note: The asterisks, ***, ** and *, denote significance at the 1%, 5% and 10% levels, respectively.*

## Appendix 5: Framework for the description and assessment of state-based R&D precincts

*Table A5.1: Framework for the description and assessment of state-based R&D precincts*

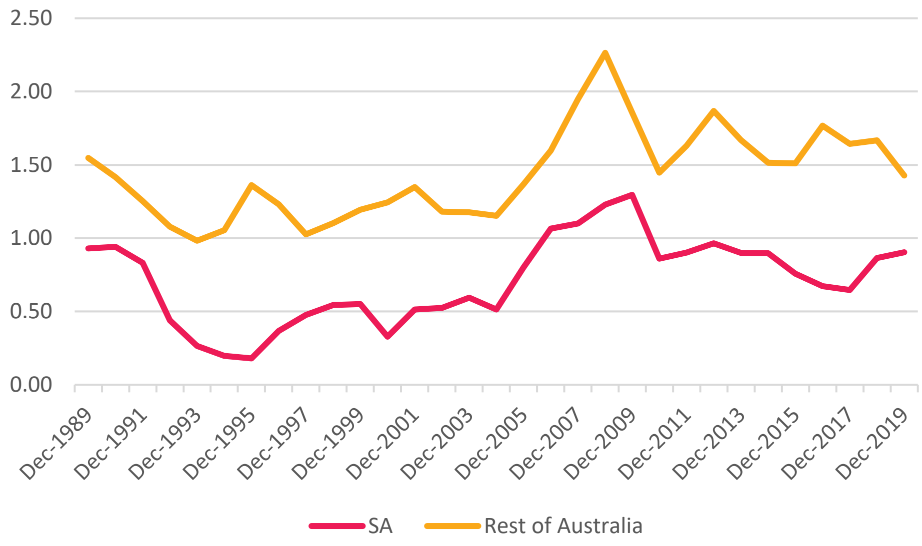
| Key criteria | Key factors | Establishment phase and/or Operational phase of precinct |
|---|---|---|
| **Leadership and governance** | Establishment of strategic vision and operational model, incorporating stakeholder requirements, and ongoing evaluation and improvement | Establishment phase |
| | The establishment of formal governance structure | Establishment phase |
| | Clear responsibilities for financing, ownership, operation and upkeep of infrastructure assets within the precinct. | Both phases |
| | Leverage of funding from stakeholders and national government | Both phases |
| | Linkage to state and national programs and priorities | Both phases |
| | Institutional, firm, and non-profit leaders innovating within their own organisation in ways that advance the precinct | Operational Phase |
| | Separation of operation and research focus from other precincts | Both phases |
| **Capacity and suitability** | Identification of major research institutions within the region | Establishment phase |
| | Identification of the advanced industry clusters and their research capabilities | Establishment phase |
| | Development of research strategies (by product or technology stream) and/or social theme | Both phases |
| | Development of formal and informal connections between research institutions | Both phases |
| | Identification of business types (mature vs start-up) and ratings of tenants' business capabilities (research strengths and collaboration) | Operational phase |
| **Commercial anchors and collaboration** | Match between research strengths of anchor institutions and industry clusters | Establishment phase |
| | Implementation and use of commercialisation mechanisms amongst precinct participants | Operational phase |
| | Size and scope for entrepreneurship within the region | Establishment phase |
| | Support for local businesses | Both phases |
| **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) | Establishment phase |
| | Adequate zoning and planning regulations to prevent dis-used spaces; separation of land use and efficient use of land by state governments | Establishment phase |
| | Suitable employment and residential densities to create interaction | Establishment phase |
| | Adequacy of private innovation spaces, common areas and equipment, accelerators and co-working spaces | Establishment phase |
| | Suitable mix of residential, commercial or public space, amenities, soft infrastructure and social activities | Establishment phase |

| Key criteria | Key factors | Establishment phase and/or Operational phase of precinct |
|---|---|---|
| | Cultural spaces, close by or in precinct | Establishment phase |
| **Scale/Critical mass** | Identification of the region's concentrations of industry | Establishment phase |
| | The location of innovation assets | Establishment phase |
| | Physical connection of industry and innovation assets in the city or the region | Establishment phase |
| | Level of start-ups and success rate in region and growth of established businesses over time | Operational phase |
| **Skills** | Sufficient numbers of researchers, inventors, entrepreneurs and workers with technical skills inside firms | Operational phase |
| | Programs in place to source key personnel | Operational phase |
| | Broad opportunity for range of workers and connection to local recruitment programs | Operational phase |
| | Connection to policies to improve STEM at schools and support for regional technical training programs | Both phases |
| **Information asset infrastructure** | Adequacy of ICT infrastructure and high-speed internet | Establishment phase |
| | Presence of national/state data repositories and data agency services | Establishment phase |

*Source: Constructed by SAPC based on The Brookings Institution, Assessing your innovation district: A how-to guide, The Anne T. and Robert M. Bass Initiative on Innovation and Placemaking, (2018).*

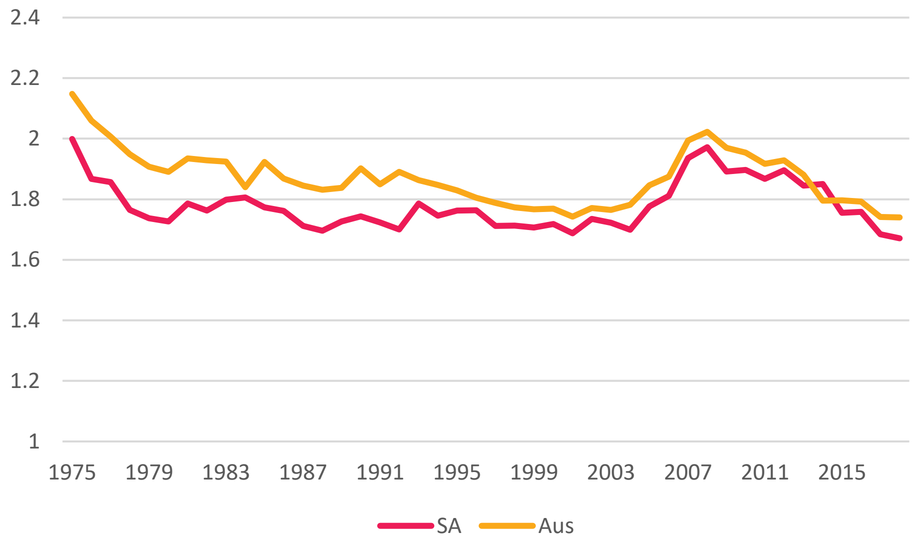
## Appendix 6: South Australian demographic indicators

*Figure A6.1: Annual population growth rates (%), South Australia and the rest of Australia*




*Source: ABS Catalogue No. 3101.0 Australian Demographic Statistics, December 2019*

*Figure A6.2: Fertility rates (number of births per woman) for South Australia and Australia.*




*Source: ABS Catalogue No. 3301.0 Births, Australia, 2018*

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