Department of Tourism, Innovation and Sport

Queensland State of Innovation

2021 Report

Queensland Government

Preface

This report is the product of the pilot phase of the State of Innovation (SOI) project, conceived, developed and implemented by the Program Design and Insights unit in the Innovation Division of the Department of Tourism, Innovation and Sport (DTIS).

The purpose of this work has been to:

1. Prove the capability of innovation ecosystem analysis within a government agency.
2. Identify available data sources across the ecosystem including some which are unavailable to private enterprise, and conduct preliminary analysis
3. Present high-level findings and observations from analysis of selected metrics and datasets
4. Promote conversations and questions about innovation in Queensland, data and metrics, and inform and influence policy development.

This report represents an initial and broad investigation into ecosystem metrics and provides additional information which formed the basis of the lines of inquiry. The trade-off to covering such breadth is a reduction in the depth of analysis. As a result, some sections of the document are not as complete as others. As the State of Innovation project develops, these sections will be fleshed out and developed further.

The intent of the SOI project is to develop rich data and insights to support evidence-based policy and decision making. Policy development to address challenges and strengthen innovation and entrepreneurship in the state is the purview of many government agencies, including DTIS.

It must be noted however that the development of a strong and viable innovation system relies on input from a wide range of stakeholders, including researchers, investors, educational institutions, startups and entrepreneurs, and associated networks and peak bodies.

Therefore, it is intended that this report and other associated SOI products – including Research and Insights Notes, data analytics and snapshot reports – will be made available to relevant stakeholders to inform and guide their priorities and actions.

Questions relating to the State of Innovation project and this report should be directed to advancequeenslandcorro@dtis.qld.gov.au

Acknowledgements

The authors acknowledge the support of colleagues from the agencies and organisations who have provided data, support, advice and feedback on the pilot phase of the State of Innovation project and iterations of this report:

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- Australian Government Department of Education, Skills and Employment
- Department of Environment and Science (and Office of the Queensland Chief Scientist)
- Department of the Premier and Cabinet
- Department of Tourism, Innovation and Sport
- Australian Bureau of Statistics
- Queensland Government Statistician's Office
- Queensland Treasury (including Office of Productivity and Red Tape Reduction)
- Queensland University of Technology
- University of Queensland

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We would also like to acknowledge Professor Scott Stern (MIT) who provided valuable feedback on the draft, in addition to providing the following encouragement for the State of Innovation project:

> *The Queensland State of Innovation Project is a timely and critical initiative for charting the future of the Queensland innovation and entrepreneurship ecosystem. Building on a strong history of innovation and entrepreneurship indicators at the State and Federal level, the Project offers the prospect of actionable insights by leveraging micro-data about innovation and entrepreneurship with data from specific initiatives and programs at a high level of granularity and timeliness. In particular, the Project will be invaluable in providing guidance and assessment for important ongoing initiatives such as Queensland Connects and Advance Queensland. Based on the rigorous yet accessible work conducted in Phase I, I look forward to the insights and research to come out of the project moving forward.*
>
> - Scott Stern, Professor of Management, MIT Sloan School of Management

The SOI pilot project and associated report were made possible with the support of and collaboration with colleagues and leadership within the DTIS Innovation Division. The Program Design and Insights team collected and collated the data and also conducted analysis of quantitative and qualitative data. The insights and views expressed in this report belong to the authors and do not represent those of the Queensland Government or DTIS. Any errors or omissions also belong to the authors.

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Executive Summary

Governments at all levels are investing in innovation with the view to stimulating the creation of jobs, investment, business productivity and new industries. The links between innovation, productivity and increased standards of living have been long established.

The innovation system is vast and complicated to measure. However, the need to account for government investments and understand their impact for policy development drives the demand for innovation metrics and data. This document is the result of an initial foray into representing the many different components of the system.

There is an opportunity to consider areas of the innovation system in Queensland, trends and comparisons with other jurisdictions to inform discussions about the future of innovation and entrepreneurship in the state.

This document is focused on Queensland, however benchmarking with other jurisdictions (e.g. Rest of Nation, other states and territories) has been included wherever possible. This provides some context or baseline into *"how things are going*". Though far from exhaustive, this report aims to generate discussion around innovation in Queensland, data and metrics. This report captures the breadth of the innovation system.

The findings of the report are summarised below, according to groupings of themes, by which this report is organised: human capability and research; innovation environment; and innovation outputs.

Human Capability and Research

- Knowledge-intensive industries require a highly skilled workforce, demanding a range of different technical skills. Queensland will need a pipeline of knowledge workers to meet the demands of a diverse economy.
- Queensland has typically relied on international students for both university revenue stream and skilled migrants for the supply of a STEM workforce. Domestic STEM enrolment has stagnated between 2015 and 2019. COVID-19 restrictions and requirements have affected the supply of international and interstate STEM students and workforce. The true impact of the pandemic is yet to be fully understood.
- STEM enrolments for female and First Nations students have increased between 2011 and 2019.
- Human capability in the innovation system needs significant investment whereby all levels of government, industry, research and education institutions and businesses have a critical role in ensuring that Queensland has the medium and long-term capability to build on its strengths.

Table 1 Key findings: Human Capability and Research

Education	**Of note:** ✓ Uptake of maths and science subjects in school education has increased, while IT participation has steadily declined. Female students remain under-represented in STEM subjects. For example, 1.2 out of 10 students studying Information Processing Systems are female. The female participation rate has however steadily increased by 4% in Physics, IT and Maths subjects (2012-2019). ✓ First Nations students in STEM courses made up 1.12% (648) of the total STEM student population in Queensland in 2019. Of those First Nations students, 40% were female. ✓ Although First Nations students make up a small proportion of STEM students, the enrolment rate increased by 93.8% and course completion increased by 167.7% between 2011 to 2019.

	Other observations: ▪ Higher Education STEM course participation has stagnated. This is likely to have an impact on the domestic supply of STEM workforce in the medium term. In 2019, females made up 34.5% (12,981) of domestic STEM enrolments and 36.4% (2,405) of completions at university. ▪ Although STEM course completion among females at university has steadily increased from 2012 to 2019, the rate of year-on-year increase among this group has been trending down over the eight-year period.
Research Institutions	**Of note:** ✓ Growth in research income in higher education institutions is outpacing the growth of research staff numbers which may have implications for future research capability and potential for commercialisation. ✓ Queensland-based universities have continued to maintain their competitive advantage in attracting research funding, education and knowledge creation.
Research and Development	**Of note:** ✓ Spending on R&D across sectors (business, higher education and government) over time has increased. ✓ The 2018-19 per capita expenditure on R&D by the Queensland Government was $121, which is equal to Victoria and higher than Western Australia ($93), New South Wales ($81) and the Australian Capital Territory ($80). ✓ In 2019-20, the Queensland Government spent over $380 million on R&D, $30 million more than the previous year and 8% more than the average expenditure over the previous five years. **Other observations:** ▪ Federal R&D tax incentives could be better utilised to encourage business expenditure on R&D.
Knowledge Workforce	**Of note:** ✓ The number of knowledge workers in Queensland has more than doubled over the 20-year period 1998 to 2018. **Other observations:** ▪ Queensland's knowledge workers make up almost 40% of the state's total workforce. However, this is lower than all Australian states and territories except Western Australia and Tasmania.

Table 2 Interjurisdictional comparisons: Human capability and research

	QLD's position among states & territories							
Metrics	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Proportion of knowledge workers in 2017-18						■		
Higher Education R&D Expenditure as a proportion of GSP in 2017-18						■		
Business R&D Expenditure as a proportion of GSP in 2017-18						■		
Government R&D Expenditure as a proportion of GSP in 2017-18					■			
Government R&D Expenditure per capita 2018-19				■				
Proportion (%) of companies claiming Federal R&D offsets in 2016-17				■				

Innovation Environment

- Queensland has a relatively high proportion of startups, and the highest proportion of startups in knowledge-intensive industries in Australia.
- Australia's technology workforce is expected to grow at 3% over the next five years, however the Australian Computer Society asserts that Australia is not on track to become a digital leader, ranking it seventh out of 16 countries.
- Queensland businesses are optimistic about using technology to improve business operations and productivity. However, many are concerned about the access to and quality of enabling technology to support their businesses to be competitive.
- Through consecutive government investment, including the Smart State Strategy and Advance Queensland, the innovation system has spurred capabilities in science, technology and innovation to contribute to the diversification of the economy.
- Queensland's performance against metrics for an innovation environment suggests that, overall, the state is performing in the middle and better in areas such as growing startups in knowledge-intensive industries.

Table 3 Key findings: Innovation Environment

Business Creation and Startups[1]	**Of note:** ✓ A 2019 survey of Queenslanders' perspectives on entrepreneurship found that regions had lower fear of failure when considering starting an enterprise. For example, entrepreneurs in the Sunshine Coast (47%) and Fitzroy (48%) regions had the lowest fear of failure, in contrast to the Brisbane (65%) and Toowoomba (61%) regions which have the highest. ✓ In 2020, the state had the highest proportion of startups (3.6% or 12,700) in Knowledge-Intensive industries. Around 1 in 140 businesses in Queensland are startups in knowledge-intensive industries. **Other observations:** ▪ The rate of business creation in Queensland is increasing, indicating a positive business environment coming out of 2020. This is, however, lower than other jurisdictions.
Digital Readiness	**Of note:** ✓ In a 2021 survey of Queensland businesses, 69% of businesses are optimistic about using technology. 53% of businesses are concerned about the lack of digital skills in the workforce. **Other observations:** ▪ Inadequate human capability and infrastructure are barriers to digital readiness and may hamper the pipeline of technology-oriented businesses to achieve high growth. ▪ In 2020, Queensland was ranked 12.62 out of 25 in the CISCO Digital Readiness Index, behind all states and territories except South Australia and Northern Territory.
Investment Attraction	**Of note:** ✓ Over half of all investors in Australia are located in New South Wales. In 2020, Queensland attracted almost a quarter (USD$2.9 billion)[2] of the total investment in Australia. **Other observations:** ▪ There is a need for better facilitation and connections between investors and investees to enable a stronger venture capital sector.

[1] For the purposes of jurisdictional comparisons, this report uses the OECD definition of startups – firms aged 0-2 years old, with the additional exclusion of Government and Superannuation entities.
[2] Crunchbase database uses US currency value.

Table 4 Interjurisdictional comparisons: Innovation Environment

Metrics	1	2	3	4	5	6	7	8
	QLD's position among states & territories							
Digital Readiness in 2020						■		
Business entry-exit ratio in 2020					■			
Startups as a proportion of young firms in 2020				■				
Proportion of startup in Knowledge-Intensive industries in 2020	■							

Innovation Outputs

- Although productivity growth has slowed in Queensland (consistent with national and global trends), the state recorded stronger growth than the rest of Australia over the last two decades.
- Queensland has consistently relied much more heavily on exports than the rest of Australia. Of Queensland's exports in 2018-19, the mining industry made up 77% (~$67.1 billion) and manufacturing 14% (~11.4 billion).
- Knowledge intensive activities are key drivers of growth, future job creation and prosperity in Queensland's economy. Knowledge-intensive trade relies on knowledge-based industries which draw heavily on technology, science, innovation and human capital inputs.
- Based on the two metrics outlined in Table 6, Queensland's performance appears to be above average. However, analysis of innovation outputs and outcomes are needed to capture the full picture of the state's performance. Other metrics include scientific and technical article publication rates, labour productivity growth, high tech manufacturing and exports and domestic industry diversification.

Table 5 Key findings: Innovation Outputs

Knowledge Intensive Services Exports	**Of note:** ✓ The state has some export advantages in traditional industries that may provide opportunities for innovators and entrepreneurs to drive growth. **Other observations:** ▪ In 2019-20, as a share of the nation's total knowledge-intensive services exports, Queensland's contribution was third highest (10.5%), significantly behind New South Wales (48.5%) and Victoria (28%).
Knowledge Creation	**Other observations:** ▪ A flattening in patenting applications in Queensland over the six years to 2018 may hamper commercialisation potential. The research sector has a role to play in developing new IP in collaboration with industry, government and community partners.

Table 6 Interjurisdictional comparisons: Innovation Outputs

Metrics	1	2	3	4	5	6	7	8
	QLD's position among states & territories							
Share of nation's Knowledge-Intensive services exports in 2019-20			■					
Number of patent applications per million residents in 2018				■				

1 Introduction

The role for government in enabling innovation to drive productivity and increase standards of living has been long established. Governments have traditionally used regulation and policy levers to create an enabling environment for innovation and entrepreneurship to thrive.

The need to account for government investments and understand their impact for policy development drives the demand for innovation data. The challenge with innovation metrics is improving measures and data to enable multilevel, granular analysis and real time monitoring.

An evidence-based approach to Queensland's innovation system is important for defining the government's role and developing appropriate policy interventions.

1.1 Challenges with Innovation Metrics

Globally, a range of composite indices have been developed. Global benchmarks, innovation metrics and indicators for international comparisons provide a rough guide of innovation performance. While international organisations such as the Organisation for Economic Co-operation and Development (OECD), World Bank and World Economic Forum (WEF) use standardised metrics and composite indices to track and compare innovation and entrepreneurship by country, these measures also have limitations. For instance, metrics to capture knowledge inputs and outputs applied to developing countries may not accurately capture innovation activities due to the lack of formal institutions for research and finance in those countries. The science around innovation measurement is evolving in tandem with the shifts in innovation paradigms and changes in economies.

The Global Innovation Index is the most recognised of these composite indices, all of which use data that are readily available and combine them using different weightings and methodologies to provide a headline number for international comparisons.[3] Such singular numbers are rarely useful for the development of policy because they lack the granularity that data users need to determine what changes in indices mean in relation to their context.

A further problem is that existing innovation metrics and composite indices do not provide comprehensive coverage of relative innovation performance in all sectors in the economy, such as resources, agriculture and service industries.

Despite the limitations of these composite indices, their simplicity means they are often referenced as the definitive source of innovation performance for Australia and Queensland.

Most international effort has been focused on measuring innovation activity rather than measuring the impact of innovation. It is easier to measure inputs and activities than outputs and outcomes, but the latter are more useful to determine whether progress is being made. Analyses of particular policies and programs are required to determine whether policies and programs are effective or require redevelopment or cessation.

In 2019, the Australian Government completed a review of innovation indicators and data available for analysis. The review found that about half of all innovation metrics identified have issues such as no or partial data for metrics. For example, of the 10 metrics related to 'non-R&D based knowledge and idea creation', only half of the data for these metrics are available or reliable. Of the 140 metrics associated with 'human capital', about 40 metrics have data with no issues.[4]

At a national level, a lack of co-ordination of innovation and entrepreneurship measurement and data collection remains a challenge. However, incremental enhancements around measurement and reporting on innovation and entrepreneurship have been realised due to efforts in the last 15 years.

[3] World Intellectual Property Organisation, Global Innovation Index 2021. https://www.wipo.int/global_innovation_index/en/2021/

[4] Department of Industry, Innovation and Science, 2019. *Improving Innovation Indicators, consultation paper*. Australian Government

Innovation data and metrics to capture the current system at the state level and to monitor trends over time pose specific challenges for state governments.[5] State governments face the following innovation data issues:

- almost all available data (except business data provided through ABS' DataLab) is aggregated to a state level or higher, making comparisons between states and territories in Australia difficult.
- lack of shared definitions related to innovation, e.g. 'startup', 'scale ups', emerging or technology industry and occupation classifications
- fragmented efforts to measure and collect data on innovation and entrepreneurship at multiple levels – Local Government Areas, regions and sectors.

These issues and challenges have frustrated analysts, researchers, policy developers and decision makers. There is interest in and consensus on the need for a clear conceptual framework for measuring the performance of innovation systems in Queensland and Australia in a way that is useful for international comparisons over time.

1.2 The State of Innovation Project

The State of Innovation (SOI) project is part of a broader data and metrics solution to understand the impact of innovation and entrepreneurship on the economy. The State of Innovation project was conceived and developed by the Innovation division of Department of Tourism, Innovation and Sport (DTIS). The project has two main components, firstly a data infrastructure will be established, and data assets will be procured, collated and made accessible to agencies, researchers, private sector stakeholders and the broader innovation community. Secondly, data assets will be used by DTIS to generate analytics and insights about innovation performance in Queensland.

The project aims to sustainably provide an objective and up-to-date picture of innovation in Queensland.

The first pilot stage (2021) set out to:

- scope data infrastructure and assets available for system measurement, including restricted microbusiness data from both the Australian Bureau of Statistics (ABS), and the Australian Business Register (ABR)
- demonstrate internal capability to produce insights at the systems level
- prove the SOI concept and demonstrate its value to a variety of audiences in government, research and industry.

An output of the pilot is this report which aims to:

- present high-level findings and observations from analysis of selected metrics and datasets
- promote conversation and questions about innovation in Queensland, data and metrics.

[5] The Department of Tourism, Regional Development and Industry formed the Science and Technology group developed an Innovation Measurement Framework (n.d). The Group also identified limitations with metrics, lack of definitions and fragmented data sources.

1.3 Knowledge Economy Framework

Knowledge economies are defined as those economies which are based on the production, distribution and use of knowledge and information.6 In this economic view, knowledge is another input of production that supports those of labour, land, capital and materials to achieve economic, social and environmental outcomes. Within this view or framework, economies can prosper through innovative practices that rely on technology, research and science.

Figure 1 Knowledge economy framework for SOI Pilot, 2021

Innovation in its various forms accounts for a substantial share of economic growth across countries. According to the OECD this is often around half of total Gross Domestic Product (GDP) growth over the long term.[7]

Given that there are no agreed national or state definitions of the knowledge economy, a working definition comprising six dimensions was developed for the purposes of this pilot to guide the selection of metrics and data for analysis (Figure 1). The metrics were selected because they provide an adequate proxy for the relevant dimension and readily available data (Table 7).

It is recognised that this framework could be more comprehensive to capture with greater accuracy the landscape of innovation in Queensland. Examples of metrics are listed in Table 7.

It is recognised that many other metrics are relevant to government policy and are required to measure dimensions of the knowledge economy and innovation system. For instance, the component of 'Talent' includes 'workforce pipeline' and could include 'talent attraction' and 'industry throughput'. Metrics and data for these components will need to be identified to better understand the challenges and trends to inform policy responses to these issues for the state.

In Phase Two of the State of Innovation project, the Innovation Measurement Framework (IMF) will be consolidated through stakeholder engagement to develop a shared understanding of the important dimensions of the innovation system, and the key metrics and indicators to capture the performance of this system.

[6] OECD. 1996. 'The Knowledge-Based Economy', STI Outlook, Paris: OECD.

[7] Department of Industry, Innovation and Science; Office of the Chief Economist: Australian Innovation System Report (2017)

Table 7 Knowledge economy framework for pilot phase: dimensions and metrics

Framework Components	Dimensions	Metrics
Ideas	Knowledge outputs	IP applications University rankings
Growth Support	Research and Development (R&D)	R&D expenditure by business, higher education and government R&D tax offset incentives
Culture and Infrastructure	Business environment	Business entry and exits Startups in the economy Startup financing Digital readiness
Market Access	Business growth Commercialisation	Knowledge-intensive service exports
Talent	Workforce pipeline	STEM participation in school and higher education University and research staffing Knowledge workforce
Financial Capital	Investment	Venture capital and later stage equity funding

1.4 Methodology and Limitations

The measurement framework for metrics used in this SOI report is drawn from the knowledge economy framework which includes dimensions such as human capability and research; innovation environment; and innovation output.

Although the SOI report is focused on the innovation system rather than at the program level, its analysis and interpretation are oriented towards government policy. As such, the significant investment in the Advance Queensland (AQ) initiative is recognised as an important contribution to the Queensland innovation system.

This framework is used in the pilot phase, with the aim of further refinement through consultations with a range of stakeholders across agencies and external to government in Phase Two of the SOI.

A set of principles guided the selection of metrics and data for the pilot of the SOI project, these include:

- ease of collection (access to existing sources) within the pilot phase (Mar-June 2021)
- reliability and accuracy
- repeatability and sustainability
- relevance to Queensland (state level data) and capturing of trends over time
- comparability (with other jurisdictions)
- relevance to departmental objectives and priorities and other recognised frameworks

Mixed methods were used to analyse quantitative and qualitative data. Most recent and available quantitative datasets are before 2020 (that is, pre-Covid 19), except:

- Australian Business Registry (ABR) data (end of 2020) as represented in the LABii data set
- CrunchBase data (as at May 2021)

At the time of the pilot, the team had limited access to the ABS BLADE core dataset and did not yet have access to the Multi Agency Data Integration Project (MADIP) datasets. These restricted datasets contain a vast range of microbusiness data and individual level data which will enable the measurement of innovation and entrepreneurship in Queensland. Future reports will draw on these data along with other sources.

Descriptive analysis was conducted using a broad range of data sets, these include:

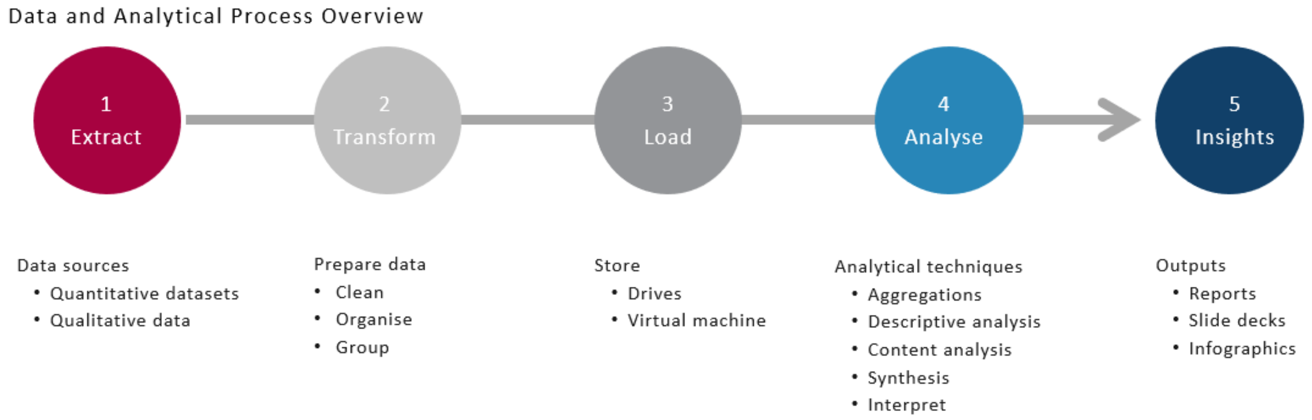
Table 8: Data sets and sources

Source	Data sets
Federal Government Agencies	**<u>Australian Bureau of Statistics</u>** • National, state and territory population, Australia Cat. No. 3101.0 • Estimates of Aboriginal and Torres Strait Islander Australians, Australia Cat. No. 3238.0.55.001 • Research and Experimental Development: Businesses, Australia Cat. No. 8104.0 (BERD) • Research and Experimental Development: Higher Education Organisations, Australia Cat. No. 8111.0 (HERD) • Research and Experimental Development, Government and Private Non-Profit Organisations, Australia Cat. 8109.0 (GOVERD) • Venture Capital and Later Stage Private Equity, Australia, 2018-19 Cat: 5678.0 • Business Longitudinal Analysis Data Environment (BLADE) 2001-2017FY, accessible via ABS DataLab only: o ATO Business Activity Statements (BAS) o ATO Business Income Tax (BIT) Other modules • IP Australia: Intellectual Property Longitudinal Research Data (IPLORD) • Department of Home Affairs: Merchandise Exports Data, • Department of Home Affairs: Merchandise Imports Data, **<u>Federal Government program administration data</u>** Department of Education, Skill and Employment • Higher Education Research Data Collection (HERDC) • University Statistics
State Government Agencies	**<u>Queensland Treasury</u>** • Australian Bureau of Statistics (ABS) Labour Force Data (Cat. 6291.0.55.003) as analysed by Queensland Treasury **<u>Office of Queensland Chief Scientist</u>** • Queensland Government research and development expenditure report 2019-20 **<u>Queensland Curriculum & Assessment Authority</u>** • Pre-2020 Year 12 Enrolment, processed and supplied by Queensland Department of Education **<u>Trade Investment Queensland</u>** • Australian Bureau of Statistics (ABS), International Trade: Supplementary Information (cat: 5368.0.55.003). Knowledge-Intensive Industries definition supplied by Trade Investment Queensland. •
University Institution	**<u>Queensland University of Technology (QUT)</u>** • Longitudinal Australian Business Integrated Intelligence (LABii) DataVault: • Australian Business Register • Intellectual Property Australia • Australian Stock Exchange List • Mergers and Acquisitions data • Export data •
Industry and Private Sector	**<u>Cisco Systems</u>** • Australian Digital Readiness Index 2018, and 2020 **<u>Queensland Productivity Commission</u>** • Queensland Productivity Update 2018-19, Research Paper, 2020 **<u>Chamber of Commerce and Industry Queensland</u>**

Source	Data sets
	• 2020 Digital readiness report **Australian Computer Society** • Australia's digital pulse: unlocking the potential of Australia's technology workforce, Deloitte 2020 **Crunchbase** (as at May 2021) • Australian Investors • Investment amounts in Australia

An environmental scan of qualitative data sources was completed, covering reports, articles and online material. Data collation and analytical steps are outlined as follows:

Figure 2 Data and analytical process for SOI pilot phase, 2021



1.4.1 Caveats and Limitations

The SOI pilot project is intended to provide a cursory glance at selected dimensions of innovation at the state level rather than a comprehensive view or assessment of the Queensland innovation system or knowledge economy. Testing data sources for quality and accessibility is also an intention of the pilot. With all methods, there are limitations and caveats.

For this pilot, the following caveats and limitations apply:

Data lag is highly variable between sources, ranging from live (e.g. Crunchbase data), to trailing by three years (e.g. ABS data). Timing also adds complications, as some sources reflect quarterly results while others are calendar or fiscal year. This presents challenges when comparing results across the same time frame and by implication, the data is historical. Although data and time lag are perennial issues, it is not a significant barrier for analysis of the innovation ecosystem and economy where improvements can be incremental and require longitudinal monitoring to understand trends and changes.

These issues are influenced by data collection intervals, methods of collection and resources to process datasets by agencies/organisations. Changes in data collection methodology or the underlying systems will naturally trigger knock-on impacts to continuity of reporting, for example:

- recent high school curriculum changes have made pre and post 2020 high school STEM data incomparable
- R&D Tax Offset data only began being collected from 2011-12FY, despite other business data going back to 2001-02FY within ABS DataLab

Availability of locational data is also patchy and is limited through the data collection process.

Micro business data in ABS DataLab and LABii dataset used in this pilot presented some challenges with working with raw data. These datasets often required significant cleaning and shaping; limited notes and data dictionary to explain variances which resulted in more effort to organise the data for analysis.

Business innovation (ABS Business Characteristics surveys) and collaboration data are excluded from this Snapshot due to restricted capacity but may be included in future analyses. The ABS has changed the collection periods and amended some questions in this survey which may affect comparability with older data and time lag.

Qualitative data is drawn from reports, papers and journal articles. Results from these sources are produced from studies which use a variety of methods making comparisons difficult and near impossible to generalise at the state level. Instead, results and insights from qualitative sources have been used to illustrate perspectives, explain context or issues and demonstrate specific examples.

At the time of this pilot, metrics and data for innovation infrastructure were not included because the data was not readily available through public site or platforms or available in micro datasets. The SOI project will endeavour to gather and incorporate data on innovation infrastructure in Queensland where possible.

2 Human Capability and Research

Higher education institutions, government and businesses all contribute to research and development (R&D) activities. A strong supply of science, technology, engineering and maths (STEM) related capabilities will be necessary for growing Queensland's knowledge economy.[8] This section presents results for the pipeline of this capability beginning with STEM education, specifically high school and university student enrolments and an overview of current knowledge workers. This is followed by an analysis of investment in R&D by businesses, higher education institutions and government.

2.1 STEM School Education

The *National STEM school education strategy 2016-2026* sets out the direction for improving STEM education.[9] STEM education enables students to develop solutions to complex problems and develop into future innovators, educators and researchers to compete globally. The Queensland Government's strategy for STEM education is outlined in the *Advancing education: An action plan for education in Queensland* (2017) and *Engaging Queenslanders in Science strategy (2021-24)* (2021).[10]

According to the Office of the Queensland Chief Scientist, the present challenge in STEM school education is increasing levels of enrolment in STEM subjects through improved student engagement, achieving excellence and teacher capability. Results from the most recent school STEM data are presented below. Results from analysis of education data illustrate trends by gender and the need to increase participation rates.

STEM school subjects include:

- Science: Biology, Chemistry and Physics
- Information Technology: Information Processing and Technology (IPT) and Information Technology Systems
- Maths: A, B and C levels

While there has been an increase in students studying science and maths subjects in the last eight years, the decline in students studying IT will affect the supply of future graduates in technology.

From 2012 to 2019, the proportion of all Year 12 secondary school students enrolling in science and advanced maths (B and C) is generally trending up (Figure 3).[11] Information technology (IT) related enrolments, however, are trending down, with less than 1 in 20 students enrolling in these subjects.

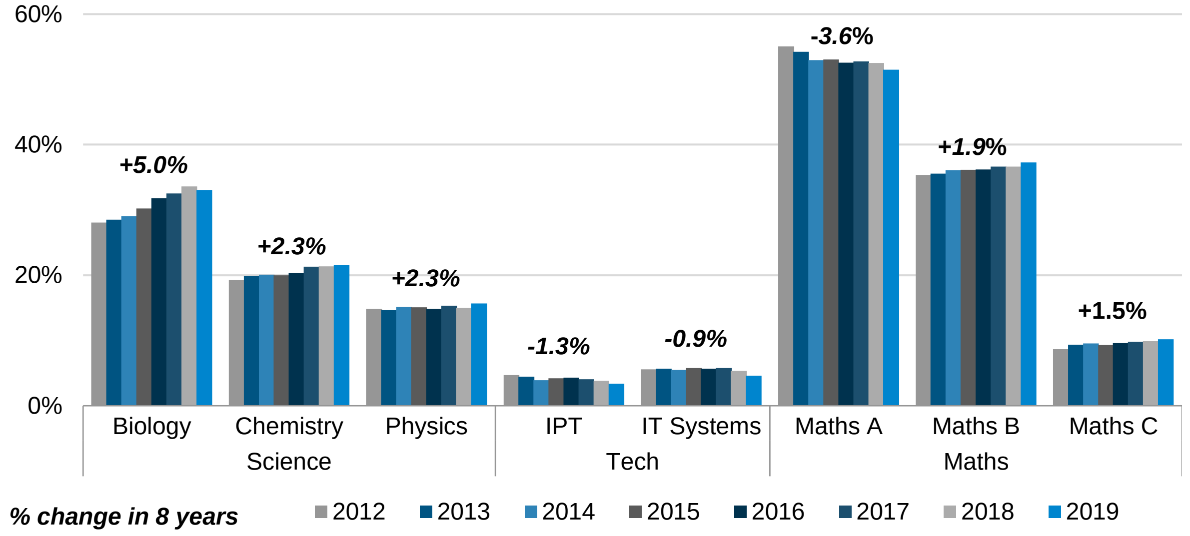
[8] https://www.chiefscientist.gov.au/sites/default/files/Australias-STEM-workforce_full-report.pdf

[9] Department of Education, Skills and Employment, *National STEM School Education Strategy 2016-2026*. Australian Government, https://www.dese.gov.au/australian-curriculum/support-science-technology-engineering-and-mathematics-stem/national-stem-school-education-strategy-2016-2026

[10] Office of the Queensland Chief Scientist, *Engaging Queenslanders in science strategy (2021-24)*. Queensland Government, https://www.chiefscientist.qld.gov.au/__data/assets/pdf_file/0029/249284/engaging-qld-science-strategy-2021-24.pdf. Department of Education, *Advancing education action plan*. Queensland Government, https://advancingeducation.qld.gov.au/ourplan/documents/advancing-education-action-plan.pdf

[11] The Queensland senior school STEM subject titles and contents may be slightly different from other states and territories. This may make jurisdictional comparisons challenging.

Figure 3: Proportion of QLD Year 12 Students Enrolled in STEM 2012-2019



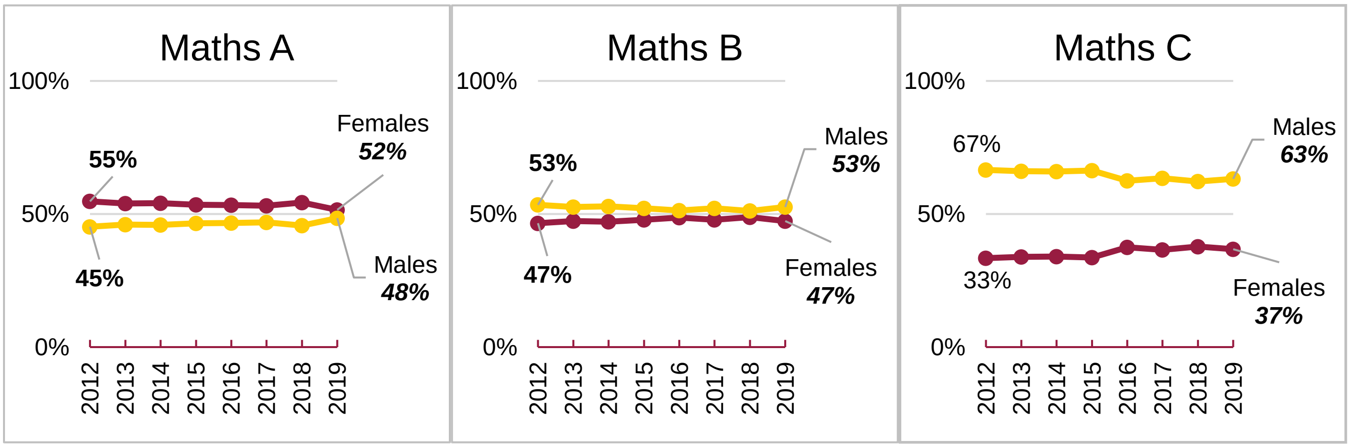
Source: Data from Queensland Curriculum & Assessment Authority, processed by Queensland Department of Education
Note: IPT: Information Processing and Technology
IT Systems: Information Technology Systems

Male students continue to dominate in advanced maths, however female student participation in this subject has been closing the gap over time.

The trend of male student participation dominating in maths subjects is consistent over the last eight years to 2019 (Figure 4). The gap between male and female students studying Maths A and B is smaller, with females making up 48% in Maths A and 47% in Maths B in 2019.

However, the gender gap in Maths C is significant with females making up 37% of students in 2019. There is an increase of 4 percentage points among female students in this subject, between 2012 and 2019.

Figure 4: Proportion of QLD Year 12 Students in Maths Subjects 2012- 2019 by Gender



Source: Data from Queensland Curriculum & Assessment Authority, processed by Queensland Department of Education

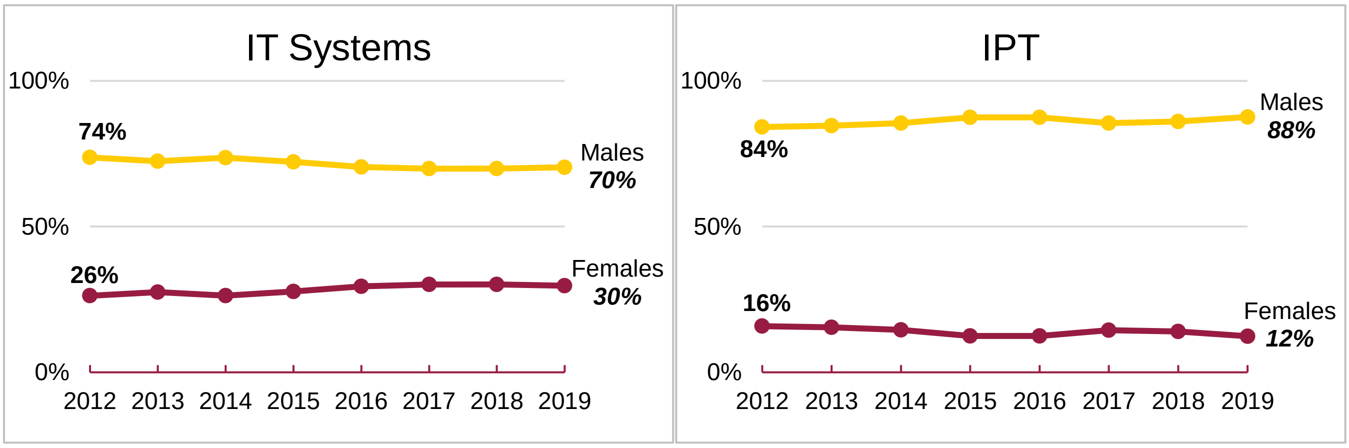
Although there is incremental growth in female students studying IT and physics subjects, female participation remains significantly under-represented in secondary school. This is likely to affect the rate of female enrolments in courses requiring foundational knowledge in maths, physics and technology.

In IT related subjects, the gender gap is stark compared with maths subjects where female students are significantly under-represented (Figure 5).

In 2019, a total of:

- 433 female students enrolled in IT systems (representing 30% of students in this subject). Over the eight-year period to 2019, there was an increase of 4 percentage point in female secondary school students.
- 158 female students enrolled in IPT (representing 12% of students in this subject). Female secondary school student numbers in this subject have slightly declined over the eight-year period by 4 percentage points.

Figure 5: Proportion of QLD Year 12 Students in IT Subjects 2012- 2019 by Gender



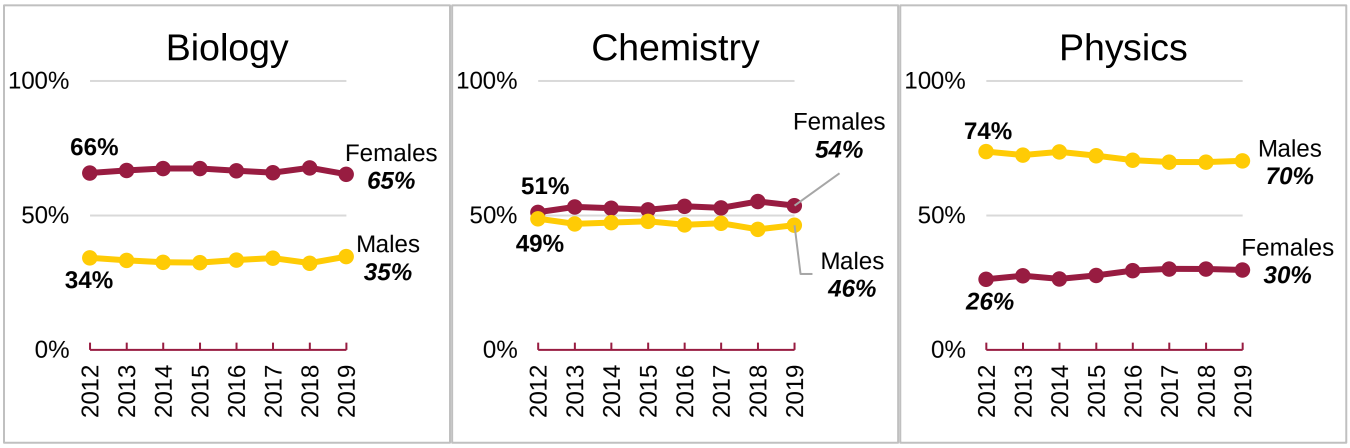
Source: Data from Queensland Curriculum & Assessment Authority, processed by Queensland Department of Education
Note: IPT: Information Processing and Technology
IT Systems: Information Technology Systems

The under-representation of female students continues in physics, with 30% of students being female (Figure 6).

Of all STEM related subjects, female secondary school student participation dominates in biology and chemistry, 65% and 54% respectively in 2019. The trend was consistent over the eight-year period between 2012 to 2019.

Among female students, there has been a minor increase in participation in physics, maths and IT systems subjects between 2012 and 2019.

Figure 6: Proportion of QLD Year 12 students in Science Subjects 2012- 2019 by Gender



Source: Data from Queensland Curriculum & Assessment Authority, processed by Queensland Department of Education

2.2 STEM University Enrolments

STEM skills are critical to the success of research and development (R&D) projects, emerging knowledge-based industries and provide a competitive advantage to established industries such as agriculture, resources and healthcare.[12] A strong STEM workforce is also critical to the Queensland's education sector which is a significant export industry.

The relationship between STEM skills, innovation and global competitiveness is established. Businesses that report using these skills are 33% more productive.[13] Labour productivity of workers in the advanced physical and mathematical sciences sector is estimated to be 75% greater than in the rest of the economy.[14]

STEM participation in Queensland universities needs to increase if the state's workforce is to be equipped for the jobs of the future and for the state to remain nationally and internationally competitive.

Over the last five years (2015-2019) domestic STEM enrolment and completion in higher education has stagnated (Figure 7). Less than one in five domestic students completed a STEM course, compared with almost one in three for overseas students.[15]

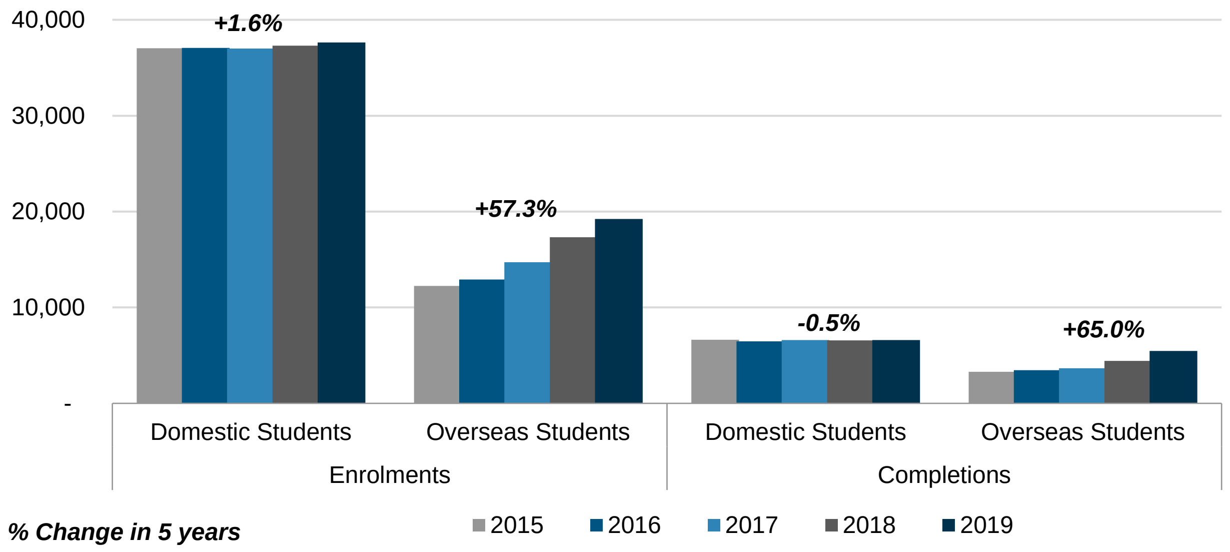
[12] For a national overview, see Office of Chief Scientist, 2016. *Australia's STEM Workforce: Science, Technology, Engineering and Mathematics, March 2016*. Australian Government, Canberra. Also see national policy goals for education and R&D in Innovation and Science Australia, 2017. *Australia 2030: prosperity through innovation*. Australian Government, Canberra. At the time of this pilot, VET STEM data was not accessed however future analysis of STEM trends will include results in this area.

[13] Palangkaraya, A. Spurling, T. and Webster, E, 2014. *Is science-based innovation more productive? A firm-level study*. Australian Council of Learned Academics, Melbourne.

[14] Office of Chief Economist, 2014. *Australian Innovation System Report 2014*. Australian Government, Canberra. Australian Academy of Science, 2015. *The importance of advanced physical and mathematical science to the Australian economy*. Australian Academy of Science, Canberra. https://www.science.org.au/files/userfiles/support/reports-and-plans/2015/importance-advanced-sciences-to-economy.pdf

[15] In future analysis drawing on additional datasets could examine other aspects of STEM participation, such as: 1) comparison of STEM and non-STEM course participation; 2) relationship between overseas student and STEM participation and 3) motivations of overseas students to study STEM in Queensland.

Figure 7: University STEM Enrolments and Completions in QLD 2015- 2019



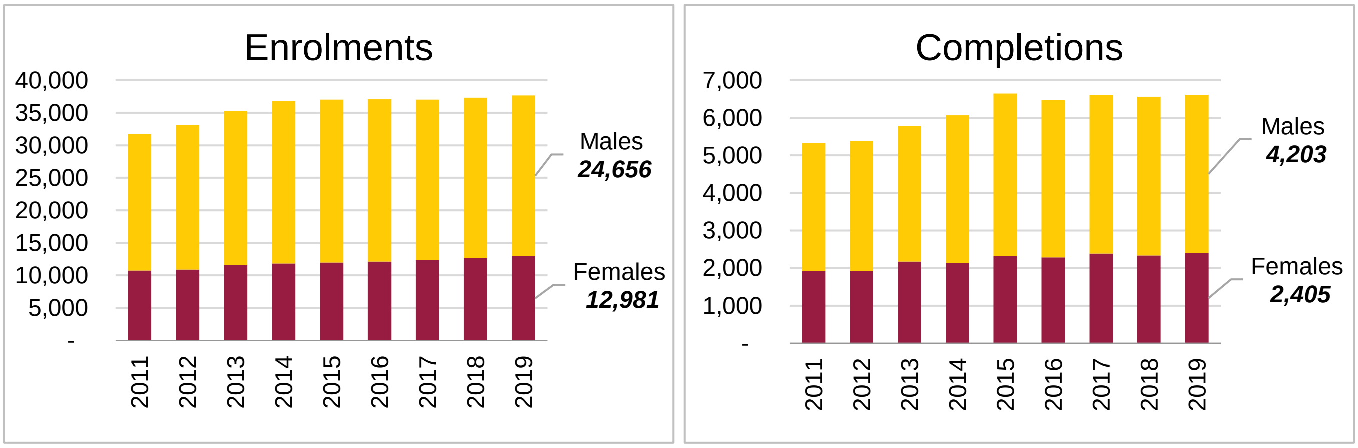
Source: University Statistics - Commonwealth Department of Education, Skill and Employment

The number of female enrolments and completions in STEM courses has increased incrementally over a nine-year period to 2019. However, the trend for year-on-year change in female enrolment and completion is downward, suggesting that female STEM graduates in higher education are declining over time.

In 2019, females made up 34.5% (12,981) of domestic STEM enrolments in Queensland and 36.4% (2,405) of completions in higher education (Figure 8). Female STEM completions at the national level are slightly higher at 37.9%. The enrolment and completion trend among male students in higher education has been almost flat in the last five years to 2019.

Among domestic female students, the number of enrolments and completions has slightly increased over the nine-year period from 2011 to 2019 (enrolments by 20.7%, and completions by 25.7%).

Figure 8: Number of Domestic University STEM Enrolments and Completions in QLD 2011- 2019 by Gender

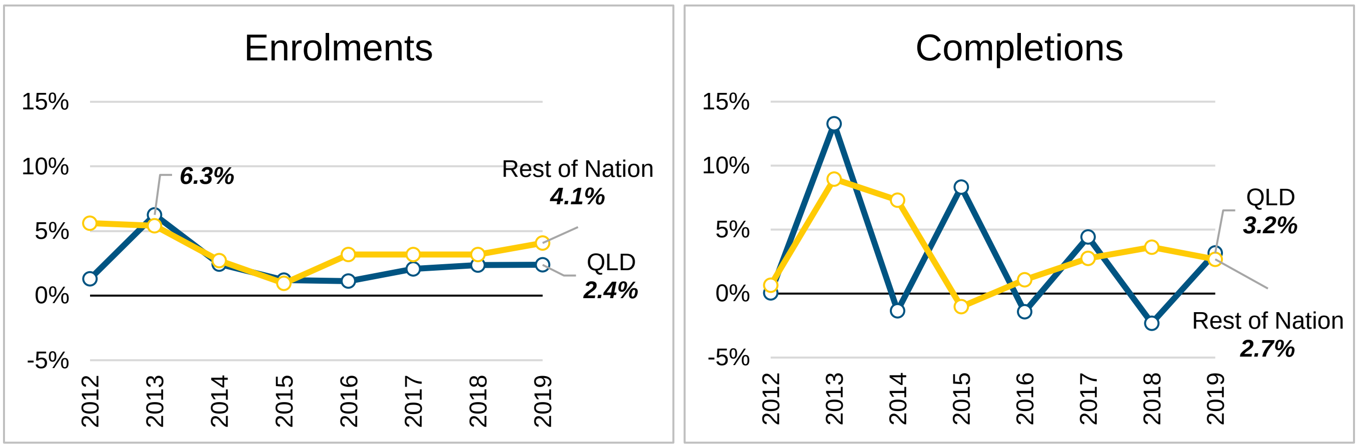


Source: University Statistics - Commonwealth Department of Education, Skill and Employment

Looking at year-on-year trends among female domestic STEM students, since 2016 enrolment increases are largely steady at about 2% in Queensland. This is lower than the rate of year-on-year increases for the rest of nation (Figure 9). Between 2012 and 2013 saw the largest year-on-year increase of enrolments among females at 6.3%.

Although STEM course completion among females at university has steadily increased from 2012 to 2019, the rate of year-on-year increase among this group has been trending down over the eight-year period. In future reports, female enrolment and completion rates in higher education will be contrasted with non-STEM courses.

Figure 9: Year-On-Year Change (%) for Domestic Female STEM University Enrolments and Completions, 2012-2019



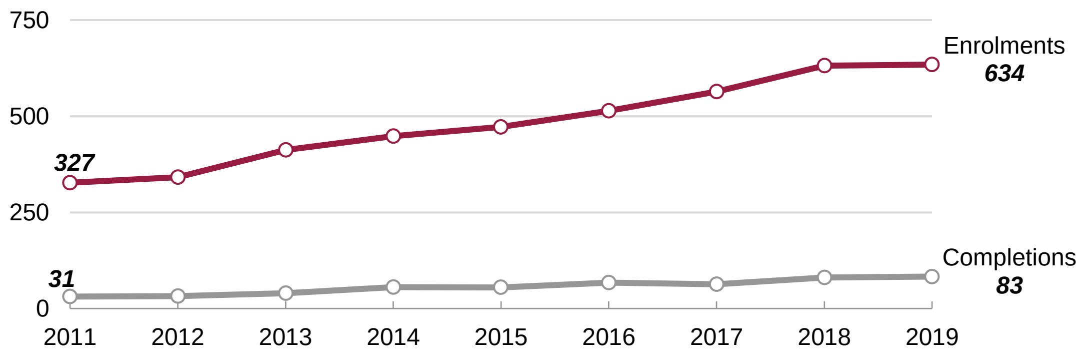
Source: University Statistics - Commonwealth Department of Education, Skill and Employment

First Nations student participation in STEM courses has increased significantly over the nine-year period to 2019. Similar to female participation rates, First Nations students remain under-represented in STEM courses in higher education.

The 2016 Census estimate of Aboriginal and Torres Strait Islanders[16] in Queensland is 4% of the total population. First Nations students in STEM courses made up 1.12% (648) of the total STEM student population in Queensland in 2019. Of those First Nations students, 40% were female.[17]

Although First Nations students make up a small proportion of STEM students, the enrolment rate increased by 93.8% and course completion increased by 167.7% from 2011 to 2019 (Figure 10).

Figure 10: Number of First Nations STEM Students in QLD Universities



% Change over 8 years**:** Enrolments: +94% Completions: +168%

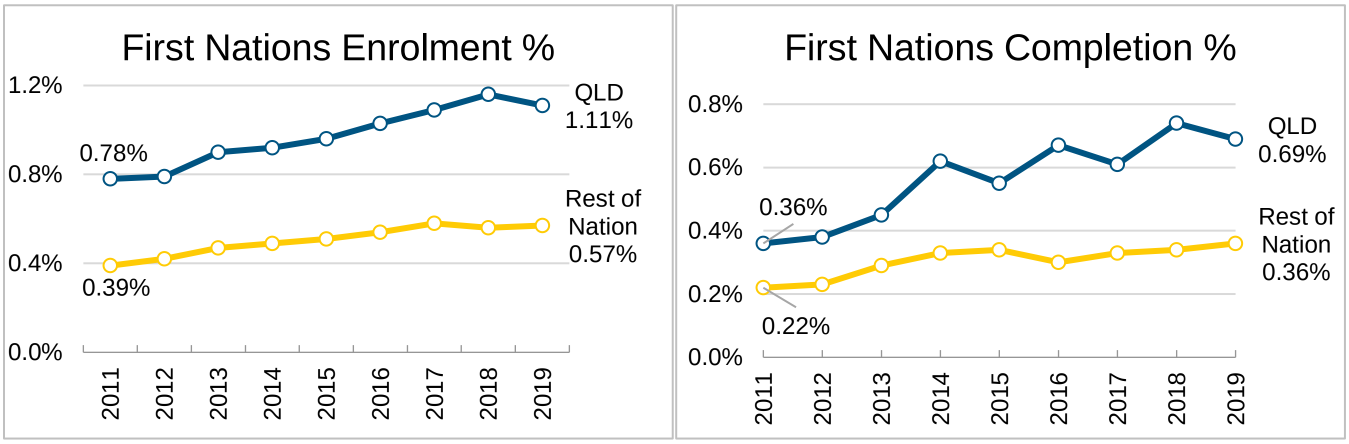
Source: University Statistics - Commonwealth Department of Education, Skill and Employment

[16] Australian Bureau of Statistics, *Estimates of Aboriginal and Torres Strait Islander Australians*, 2016, Australia Cat. 3238.0.55.001

[17] In future analysis, where additional datasets can be obtained, First Nations student participation in non-STEM courses will be compared with STEM courses.

From 2011 to 2019, relative to Rest of Nation, Queensland had a higher percentage of First Nations enrolments and completions in STEM courses (Figure 11), second only to Northern Territory for both. In future analysis, First Nations participation in STEM courses will be compared with other jurisdictions in relation to their First Nations population.

Figure 11: First Nations STEM Enrolment and Completion, 2011-2019, QLD and Rest of Nation



Source: University Statistics - Commonwealth Department of Education, Skill and Employment

2.3 Research Institutions

Universities and research institutes play a critical role in driving knowledge creation, innovation and research application across emerging knowledge-intensive industries and traditional industries. In addition to creating new knowledge, research activity is an important driver of skill development. Research is becoming increasingly data-intensive and multi-disciplinary.

Queensland is home to high quality researchers and universities. The state is well placed to be a leader in the innovation economy and support entrepreneurship in the state.

Queensland is home to 10 of Australia's universities, and these universities are recognised nationally and internationally for their strengths in science domains. For example, according to the World University Rankings, across the categories of "Engineering & Technology" and "Life Sciences & Medicine", the University of Queensland (UQ) ranks in the top 10% of universities, while the Queensland University of Technology (QUT) ranks in the top 20%.[18] Queensland has four universities in the top 250 in the world.[19] The University of Queensland (UQ) is one of three Australian universities in the global Universitas 21 and the Queensland University of Technology (QUT) is in the top 20 universities in the world for communication and media studies.[20]

Queensland based universities have continued to maintain their competitive advantage in attracting research funding, education services and knowledge creation.

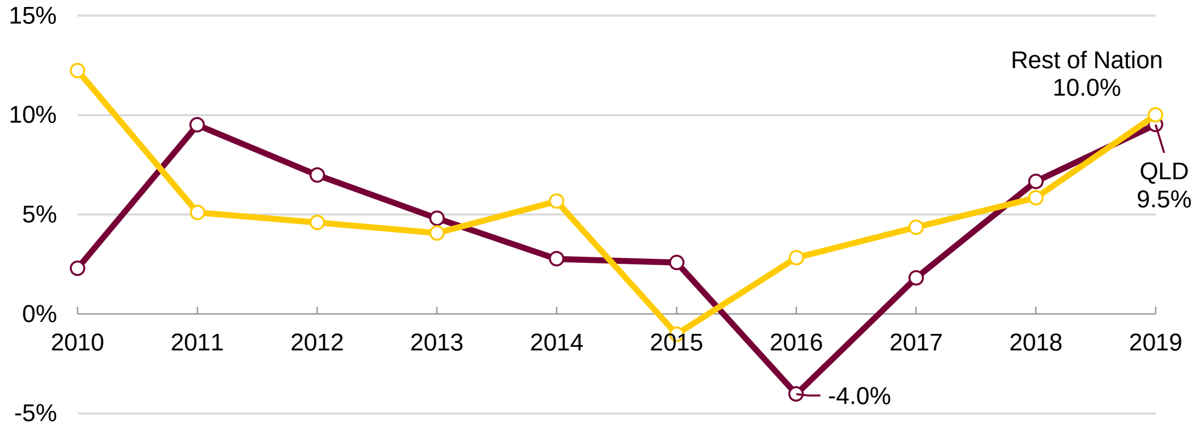
Many Queensland universities and research institutes have developed their own commercialisation entities, such as UQ's UniQuest, QUT's Bluebox and USC's Innovation Centre. These entities aim to commercialise their intellectual property (IP) through spin-out companies and improve the translation of research and technology outputs. These commercialisation initiatives focus on transferring IP out of universities and research institutes for broader use.[21] A study by Data61 on Queensland's knowledge-

[18] QC University Rankings, 2021, https://www.topuniversities.com/
[19] Times Higher Education Rankings: https://www.timeshighereducation.com/world-university-rankings/2020/world-ranking#!/page/0/length/25/sort_by/rank/sort_order/asc/cols/stats
[20] QC University Rankings, 2021, https://www.topuniversities.com/
[21] Naughtin C, Horton J, Pham H. 2019. New smarts: Supporting Queensland's knowledge-intensive industries through science, research and innovation. CSIRO Data61: Brisbane, Australia.

intensive industries concluded that the research sector also has a role to play in developing new IP in collaboration with industry, government and community partners.[22]

Research income of Queensland universities has increased consistently from 2016 to 2019, comparable with the Rest of the Nation (Figure 12).

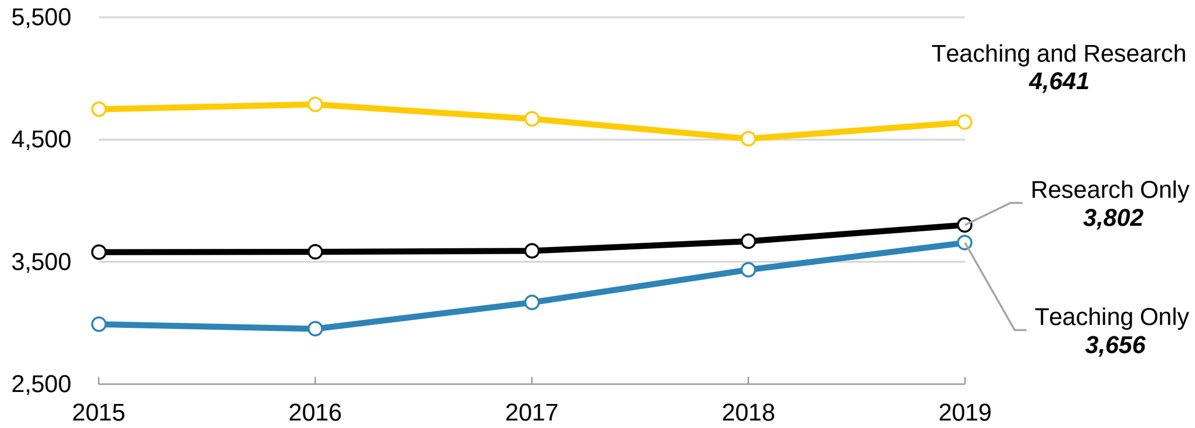
Figure 12: Year-on-Year Change (%) in University Research Income 2015- 2019



Source: Higher Education Research Data Collection (HERDC) - Commonwealth Department of Education, Skill and Employment

Over a five-year period (2015 to 2019), 'research only' FTEs increased by 6.2%, in contrast with 'teaching only' FTEs which increased by 22.3% over this period (Figure 13).[23]

Figure 13: Number of QLD University FTEs 2015-2019 by Function



% Change over 5 years: T&R: -2.2% R: +6.2% T: +22.3%

Source: University Statistics – Commonwealth Department of Education, Skill and Employment

[22] Ibid, p.70.

[23] At the time of this pilot, data for the period of 2020-2021 was not yet available. The impact of Covid-19 on university staffing and income is significant.

2.4 Knowledge Workforce

Queensland's knowledge workforce has grown over the past two decades, though it lags behind other states like South Australia, New South Wales and Victoria. To remain competitive, investment in Queensland's current and future knowledge workforce will need to increase to meet demand.

While there is a role for all levels of the education sector to respond to changing requirements, increasing demand for university curricula to be responsive to emerging knowledge-intensive industry needs, such as smart mining, exploration and extraction and advanced manufacturing. According to recent studies, universities, in collaboration with government and industry, could support talent attraction in these industries by promoting new education offerings and career pathways and including industry placements as part of degrees.[24]

Knowledge workers are at the heart of the innovation economy and critical to remaining competitive in the digitally enabled economy of the future. The technology workforce has grown at a faster rate than other parts of the labour market. The greatest job demand will include data analysts and scientists, Artificial Intelligence and machine learning specialists and big data specialists.[25]

While the number of knowledge workers in Queensland has more than doubled over 20 years, the state will need a pipeline of knowledge workers to meet the demands of a diverse economy. A recent study by Data61 found:[26]

- Queensland's knowledge workers made up 39.8% (816,022 workers) of the state's total workforce in 2017-18 (Figure 14)
- knowledge workers made up the highest share of the workforces pertaining to Professional, Scientific and Technical Services and Other Services
- when compared with other states, Queensland falls near the lower end in terms of the proportion of its workforce in knowledge-related occupations, behind the Australian Capital Territory, New South Wales, Victoria, Northern Territory and South Australia.

According to this study on Queensland's knowledge workforce, one reason for this lag is that the rate of Queensland workers with STEM qualifications is 15.3% below the national average of 17.4%. The growth of this workforce is projected to be much slower than other fields over the period 2018-2022 due to a lack of industry pathways; shortage of STEM qualified teachers; a need to increase student engagement in STEM and a need for policy intervention to grow this workforce with domestic talent and international migration.[27]

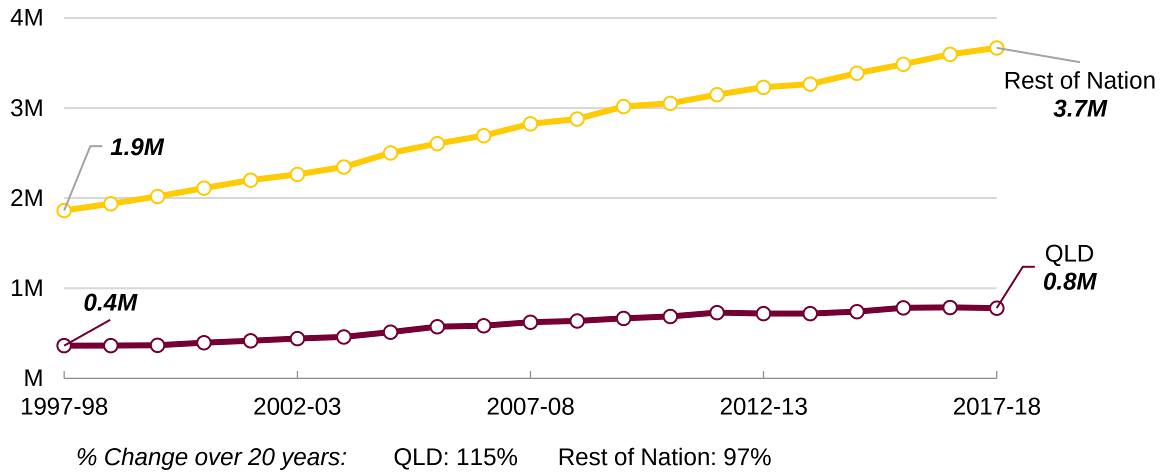
[24] Naughtin et al, 2019. Naughtin C, Moyle C, Pandey V, Renando C, Poruschi L, Torres de Oliveira R, Doan N, Schleiger E (2021). *A new chapter: Opportunities to seed new industries for Queensland over the coming decade*. Brisbane, Australia: CSIRO and Queensland University of Technology. Verreynne M., Torres de Oliveira R., Mention A-L., (2021), *Enablers and barriers to industry-research collaboration: A small and medium sized enterprise perspective.* CSIRO, Australia.

[25] World Economic Forum, see: The Future of Jobs Report 2020, World Economic Forum

[26] Naughtin C, *et al*. 2019. This study used the ABS Labour Force Data (2016), quarterly figures (cat. 6291.0.55.003). 'Knowledge workers' are defined as those employed as managers and administrators, professionals and associate professionals.

[27] Naughtin C, *et al*. 2019, p. 5.

Figure 14: Number of Knowledge Workers 1997-98 – 2017-18



Source: Australian Bureau of Statistics (ABS) Labour Force Data (cat. 6291.0.55.003) as analysed by Queensland Treasury

The importance of STEM skills in the future workforce is established in addition to that of entrepreneurial and innovation skills, both of which will increasingly become more valuable to assure Queensland's economic advantage. Institutional stakeholders in the innovation ecosystem are already making efforts to improve human capabilities. Examples include Queensland universities offering courses, programs and activities targeting entrepreneurialism and innovation.[28] In future updates on this metric, knowledge workers as a proportion of the labour force in Queensland will be provided.

2.5 Research & Development

Science and research are major drivers for knowledge creation, skills and technological development and economic competition. Research and development (R&D) directly influence the strength and competitiveness of industry by providing a basis for technological change and encouraging economic development. Investment in R&D not only realises benefits to the economy, but addresses social and environmental challenges, which in turn improves quality of life.

2.5.1 Expenditure on R&D by Sectors

At the national level, Gross Expenditure on R&D (GERD) is a key measure for aggregate R&D activity.[29] In dollar terms, the total GERD in Australia increased between the period 2008-09 and 2018-19 by $4.7 billion.[30] However, as a proportion of Gross Domestic Product (GDP), the total R&D expenditure has decreased over this time.

Closely related to business innovation is funding for experimental development to produce new materials, technologies, products or processes. At the national level, the most recent (2017-18) total Business Expenditure on R&D (BERD) makes up over half (52.7%) of the total GERD.[31] In this way, business expenditure on R&D makes a significant contribution at the aggregate level.

[28] Examples include: Bond University produces the highest number of entrepreneurs per student capita according the League of Scholars (https://bond.edu.au/news/69726/bond-leads-start-success-stories). The University of Queensland Ventures initiative entrepreneurship is a cross discipline and sectoral approach to entrepreneurship skills and mindset (https://ventures.uq.edu.au/about). QUT Entrepreneurship also focuses on providing opportunities for the next generation knowledge workers and collaboration (https://www.qut.edu.au/about/entrepreneurship). Griffith University's Griffith Innovate also provides opportunities for students, staff and industry partners to collaborate on innovative projects (https://www.griffith.edu.au/griffith-innovate).

[29] The GERD includes R&D expenditure by businesses, government (Commonwealth, states and territories) and private not for profit organisations.

[30] Australian Bureau of Statistics, *Research and Experimental Development, Businesses*, Australia Cat. 8104.0

[31] Ibid.

Funding and/or support of higher education R&D provides a measure of business and research sector collaboration. Australia's BERD conducted by higher education institutions (4.9%) is below the OECD average of 6.2% in 2018.[32] This below average rate has been persistent for over 15 years.

Spending on R&D across sectors (business, government and higher education) over time, has increased.

Expenditure on R&D in the state by all sectors has increased since 2013-14. Increases include the following:

Table 9 R&D Expenditure in Queensland across sectors

Year	Business Expenditure	Government Expenditure	Higher Education Expenditure
2019-20	$2,235M		
2018-19		$616M	
2017-18			$2,000M
2016-17			
2015-16	$1,955M		
2014-15		$520M	
2013-14			$1,668M

Source: Australian Bureau of Statistics Research and Experimental Development, Business, Australia 2019-20, Cat. 81040. Australian Bureau of Statistics, Research and Experimental Development, Higher Education Organisations, Australia 2018. Australian Bureau of Statistics, Research and Experimental Development, Government and Private Non-Profit Organisations, Australia 2018-19 financial year.

When contrasting R&D expenditure as a proportion of Gross State Product, Queensland is behind other states and territories.

Queensland's Gross State Product (GSP) as a share of Gross Domestic Product (GDP) is the third largest (19%) after New South Wales (32%) and Victoria (24%). However, the state's performance in relation to R&D expenditure by businesses, higher education institutions and government as a proportion of its GSP is lower than states and territories with a smaller GSP (Table 10).

[32] Department of Industry, Science, Energy and Resources, 2020. *Australian Innovation System Monitor 2021* March edition. The Commonwealth of Australia, p.90.

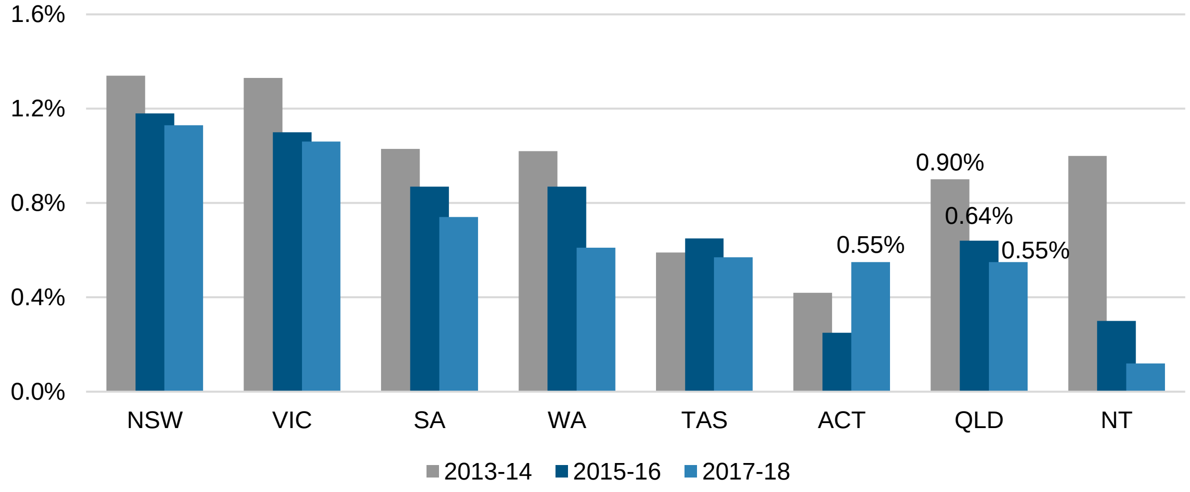
Table 10: R&D expenditure as a share of GSP, ranking by GSP size[33]

		R&D expenditure as share GSP ranking		
GSP Size Order (June 2018)	**State**	**Higher Ed Expenditure** (2018)	**Business Expenditure** (2018FY)	**Government Expenditure** (2019FY)
1	NSW	4	1	7
2	VIC	2	2	5
3	**QLD**	**5** (↓2)	**5** (↓2)	**6** (↓3)
4	WA	6	6	8
5	SA	2	3	3
6	ACT	1	5	1
7	TAS	3	4	2
8	NT	7	7	4

Total expenditure on R&D across all sectors, as a proportion of GSP has declined. Compared with other jurisdictions, in 2017-18 the level of R&D spending as a proportion of GSP in Queensland was sixth highest by businesses (0.54%) and equal sixth highest by higher education institutions (0.55%)

Except for the Australian Capital Territory, all states and territories had a declining BERD as a proportion of GSP over the five years to 2017-18 (Figure 15). Queensland had the sixth highest level of BERD as a proportion of GSP (0.6%) tied with the Australian Capital Territory (Figure 15).

Figure 15: Business Expenditure on R&D as a Proportion (%) of Gross State Product (GSP) 2013-14 – 2017-18 by States and Territories



Source: Australian Bureau of Statistics (ABS), Research and Experimental Development: Businesses, Australia Cat. No. 8104. 2017-18, 2015-16 and 2013-14 financial years.

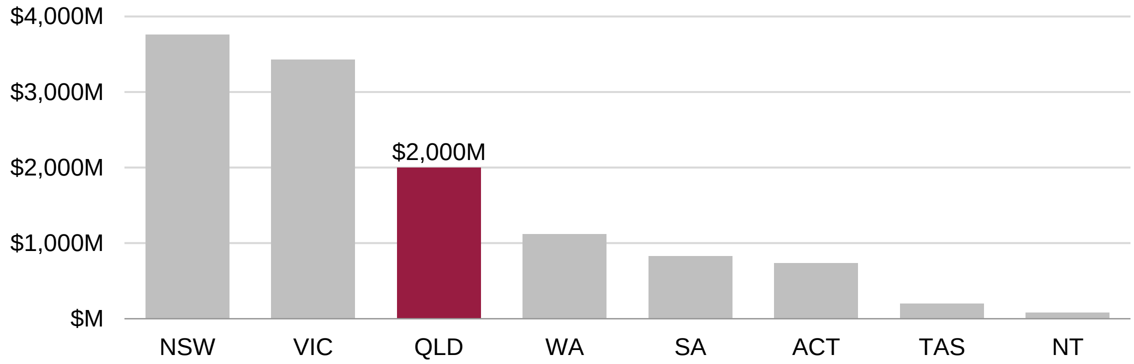
Queensland lags behind New South Wales and Victoria in the rate of spending increase on Higher Education Expenditure on R&D (HERD).

In 2018, higher education institutions based in New South Wales, Victoria and Queensland made up 76% of all HERD expenditure in the country: $3.7 billion, $3.4 billion, and $2 billion respectively (Figure 16).[34]

[33] Based on multiple sources from the Australian Bureau of Statistics, noting that data is asynchronous due to the timing of data collections: Australian National Accounts: State Accounts, Australia Cat. No. 5220.0; Research and Experimental Development – Businesses/Higher Education Organisations/Government and Private Non-Profit Organisations.

[34] Australian Bureau of Statistics, Research and Experimental Development, Higher Education Organisations, Australia Cat. 8111.0, 2018.

Figure 16: Higher Education Expenditure on R&D, 2018 by States and Territories



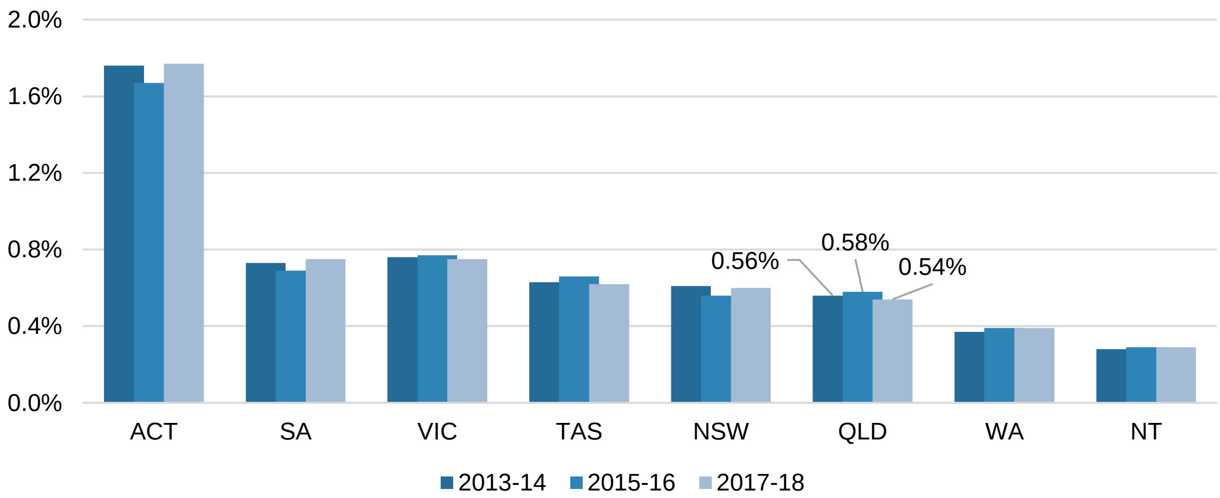
Source: Australian Bureau of Statistics, Research and Experimental Development, Businesses, Australia, Cat. No. 8104.0, 2018.

All states and territories increased their HERD spending in dollar terms. Compared with other locations, institutions in Queensland had the lowest increase (4.2%) in spending on R&D since 2015-16.

Locations with the highest increase from 2015-16 to 2017-18 include South Australia (17%), New South Wales (17%), Australian Capital Territory (16%) and Western Australia (14%).[35]

From 2015-16 to 2017-18, HERD spending as a proportion of GSP increased in South Australia (9%), New South Wales (7%), and the Australian Capital Territory (6%) (Figure 17).

Figure 17: Higher Education Institution Expenditure on R&D as a Proportion (%) of Gross State Product (GSP), 2013-14 – 2017-18 by States and Territories



Source: Australian Bureau of Statistics, Research and Experimental Development, Higher Education Organisations, Australia, Cat. No. 8111.0, 2018

In 2017-18, Queensland had the sixth highest HERD spending as a proportion of GSP (0.5%). The Australian Capital Territory had the highest expenditure of 1.8% of GSP.[36]

Between 2015-16 and 2017-18, Queensland had the largest decrease of HERD spending as proportion of GSP (7%) followed by Tasmania (6%).[37]

[35] Ibid, 2016 and 2018.
[36] Australian Bureau of Statistics, Research and Experimental Development, Higher Education Organisations, Australia Cat. 8111.0, 2018.
[37] Ibid.

Over a ten-year (2008-2018) average, HERD spending as a proportion of GSP was highest in:

- the Australian Capital Territory (2%),
- Victoria and South Australia (both 0.7%),
- New South Wales and Tasmania (both 0.6%) then
- Queensland (0.5%)[38]

HERD spending as proportion of GSP in Queensland significantly increased (37%) in 2010 from 2008, the second highest in the country after the Northern Territory (57%).[39]

Queensland is making significant gains in Government Expenditure on R&D (GOVERD) in terms of spending increase over time.

Victoria ($803 million), New South Wales ($658 million) and Queensland ($616 million) accounted for over half (62%) of total GOVERD in 2018-19.[40]

Queensland recorded the largest increase of government investment in R&D, in dollar terms: an increase of $78 million between 2016-17 and 2018-19 (up 14%) and an increase of $18 million (up 4%) between 2014-15 and 2016-17.[41]

The per capita expenditure on R&D in the state by the Queensland and Australian Governments was $121 (2018–19) equal with Victoria and higher than Western Australia ($93), New South Wales ($81) and the Australian Capital Territory ($80).[42]

Over a ten-year period (2008-09 to 2018-19), Queensland had an average increase of 6% in government spending on R&D, the second highest in the country after the Northern Territory (7%).[43]

In 2017-18, Queensland’s government spending on R&D as a proportion of GSP was the fifth highest (0.2%), above New South Wales (0.1%) and Western Australia (0.1%).

Government spending on R&D as a proportion of GSP is highest in the Australian Capital Territory in the years 2014-15, 2016-17 and 2018-19 (1.3%, 1% and 0.8%).

2.5.2 Queensland Government Expenditure on R&D in 2019-2020

Queensland Government investment to support research and development has been trending up slightly over a 16-year period and peaked in 2010-11.

In 2019-20, approximately $380 million was spent on R&D, $30 million more than the previous year and 8% more than the average expenditure over the last five years (Figure 18). 41% of R&D expenditure was leveraged from external sources, lower than the previous year (51%).

The top five agencies with reported R&D expenditure in 2019-20 were[44]:

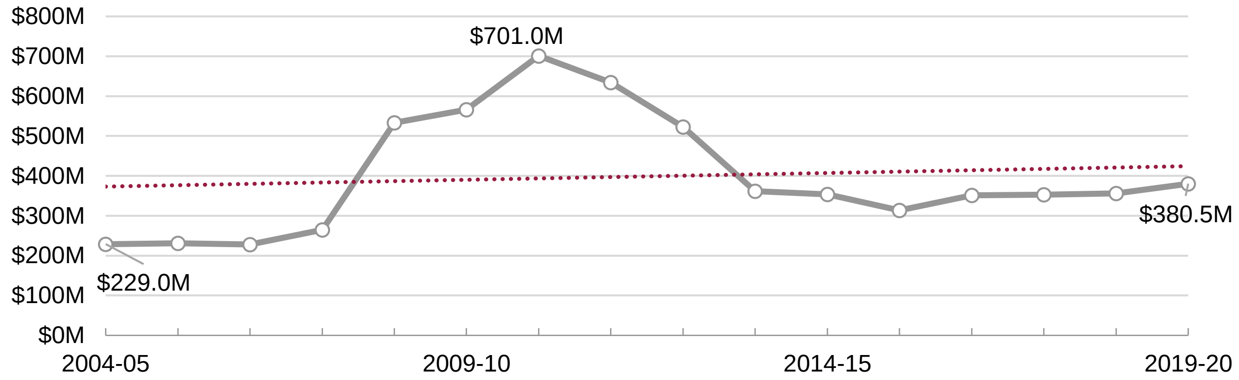
- Queensland Health ($125.5 million)
- Department of Agriculture and Fisheries ($95.5 million)
- QIMR ($50.3 million)
- Department of Innovation, Tourism and Industry Development ($34.2 million)
- Motor Accident Insurance Commission ($17.7 million)

The spike in R&D expenditure during the period from 2008 to 2014 (Figure 18) reflects the significant Queensland Government investment in research infrastructure under the Smart State Strategy.

[38] Ibid, 2008 to 2018.
[39] Ibid.
[40] Australian Bureau of Statistics, Research and Experimental Development, Government and Private Non-Profit Organisations, Australia Cat. 8109.0, 2018-19.
[41] Ibid.
[42] Ibid.
[43] Ibid.
[44] Office of Queensland Chief Scientist, 2021. Queensland Government research and development expenditure report 2019-20, Queensland Government

Institutions such as the Translational Research Institute at Woolloongabba, the QIMR Berghofer Medical Research Institute at Herston, the Health and Food Sciences Precinct at Coopers Plains, and the Ecosciences Precinct at Boggo Road, Dutton Park are the outcomes of that investment.[45]

Figure 18: QLD Government Expenditure on R&D 2004-05 – 2019-20



Source: Office of Queensland Chief Scientist, 2021. Queensland Government research and development expenditure report 2019-20, Queensland Government

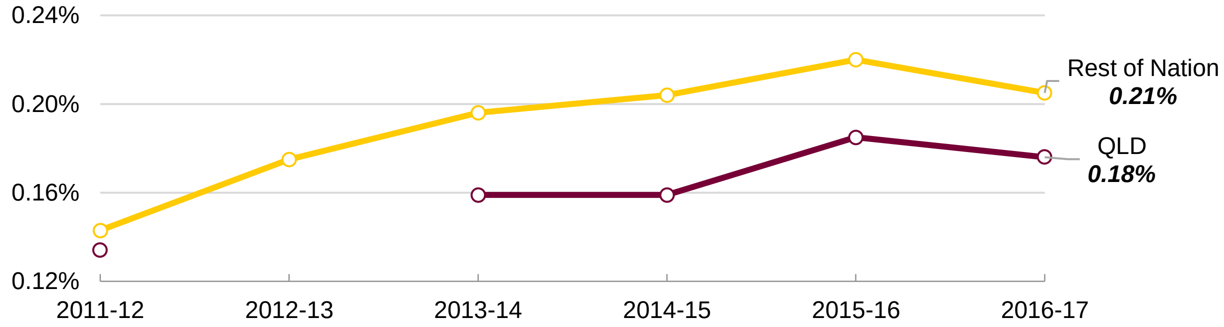
2.5.3 R&D Tax Offset Incentives for Businesses

Queensland businesses could make better use of the Australian Government's R&D tax offset incentive.

Governments also support R&D by offering businesses a tax relief for R&D related activities and by raising awareness of the technological opportunities available to reduce both the cost and uncertainty of research and innovation. The Australian Government's industry R&D tax measures are estimated to be the second largest (22%) component of the total government R&D investment after research block grants (25%) in 2020-21.[46]

Over a 6-year period (2011-12 to 2016-17), the proportion of Queensland businesses claiming R&D tax offsets increased by 0.05 percentage points (Figure 19). In 2016-17, Queensland was fourth among states and territories in businesses claiming the R&D tax offset.

Figure 19 Proportion of Businesses Claiming R&D Tax Offset 2011-12 to 2016-17



Note: Missing data due to confidentiality protection as required by ABS.

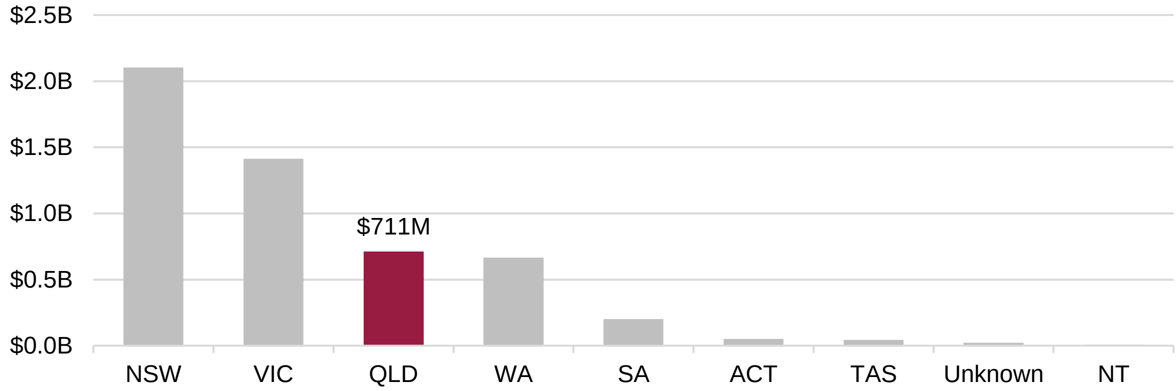
Source: Australian Bureau of Statistics 2001-2017, Business Longitudinal Analysis Data Environment (BLADE), (2001-02 to 2016-17FY). Detailed Microdata, DataLab. Findings based on the use of ABS Microdata.

[45] Ibid p.9.

[46] Seven major programs make up approximately 75% of the Australian Government's investment in R&D, these include: Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australian Research Council (ARC), Cooperative Research Centres (CRCs), Rural Research and Development Corporations (RDCs), National Health and Medical Research Council (NHMRC), R&D tax measures and research block grants. Department of Industry, Science, Energy and Resources, 2020. *Australian Innovation System Monitor*. Commonwealth of Australia, p.61.

Queensland businesses in 2016-17 claimed 13.6% (or $711 million) of the nation's business R&D Tax Offset (Figure 20). Western Australia, following Queensland, their businesses claimed 12.8% (or $666 million) of R&D Tax Offset. Businesses in New South Wales claimed the highest amount of R&D Tax Offset followed by businesses in Victoria.

Figure 20: Value ($) of R&D Tax Offset Claimed by Businesses 2016-17, by States and Territories[47]



Source: Australian Bureau of Statistics 2001-2017, Business Longitudinal Analysis Data Environment (BLADE), (2001-02 to 2016-17FY). Detailed Microdata, DataLab. Findings based on the use of ABS Microdata.

[47] "Unknown" stats are an artifact of businesses not having complete locational data within ABS's BLADE data.

3 Innovation Environment

Entrepreneurship[48] is an essential part of business birth, growth, decline and impact in market economies, or what is termed as 'business dynamism'. Conditions that enable this business dynamism include the flow and cycle of talent, capital and other resources displaced by economic competition and technological change. Business dynamism affects employment through changes in job creation and destruction, for instance a lack of business dynamism could lead to a stagnation in productivity and wage growth.[49]

Some short-term indicators of Australia's entrepreneurial activity are presented below, these include business creation, an estimation of the number and proportion of Queensland startups, recent data on business confidence, and business perception of digital readiness to innovate or to undertake entrepreneurial activities.

3.1 Business Creation

Generally, the number of businesses entering the market is lifting the number of businesses in operation.

Business entries and exits reflect business dynamism and may be used as proxy indicators for the prevailing conditions for entrepreneurial activity. [50] The ratio of businesses entering to businesses exiting the market per financial year is a proxy measure which captures the simultaneous creation of new businesses and the closure of established ones. New businesses are essential to driving innovation and delivering it to market.

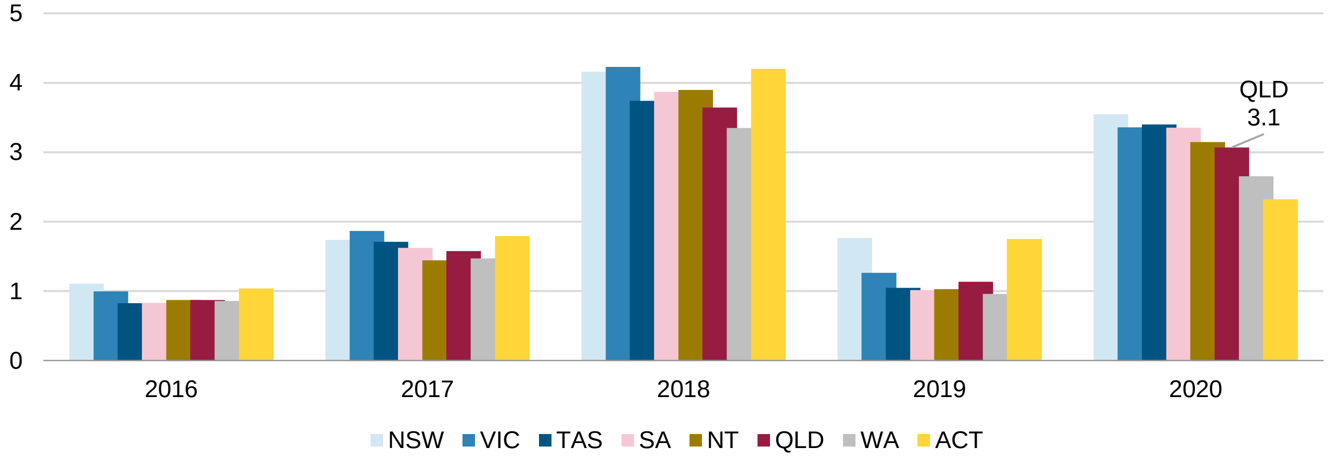
Economic conditions in Queensland are broadly supportive of business creation.

The trend for businesses entering and exiting the market in Queensland has been consistent with the Rest of Nation (Figure 21) across all years.

Generally, this has been increasing since 2016, suggesting that Queensland is conducive to business creation.

In 2020, Queensland had the sixth highest business entry to exit ratio compared with other states and territories.

Figure 21: Entry to Exit Ratio of Businesses 2016- 2020 by States and Territories

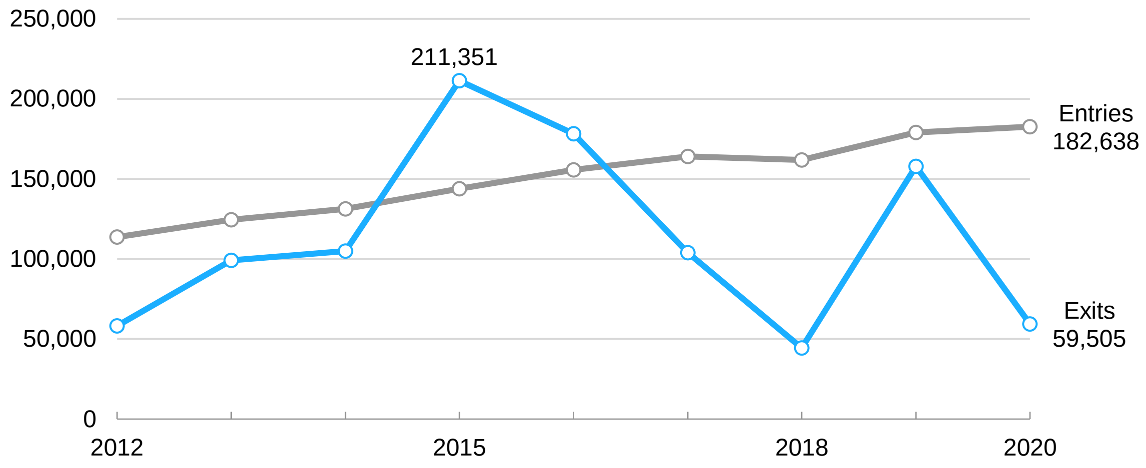


Source: Longitudinal Australian Business Integrated Intelligence (LABii) DataVault - OUT

[48] This report uses the terms 'entrepreneurship' and 'innovation' distinctively – see Appendix A for definitions of both terms.
[49] United Kingdom, Office of National Statistics, Business dynamism in the UK economy: Quarter 1 (Jan-Mar) 1999 to Quarter 4 (Oct- Dec) 2019.
[50] In this paper, business counts are inclusive of those not registered for GST. This contrasts with the methodology employed by the ABS in their Counts of Business Entries and Exits reporting.

Queensland business exits appear to have stabilised following a sharp increase in 2019 (Figure 22). COVID-19 onset in 2020 appears to have had negligible impact on Queensland business entry trends.

Figure 22: Number of QLD Business Entries and Exits, 2012 -2020



Source: Longitudinal Australian Business Integrated Intelligence (LABii) DataVault - QUT

While business entry and exits provide a proxy indicator for the general business environment, job creation is a better outcome metric for growth. Job creation by new and young businesses is important to understanding economic growth, in particular innovative new and young businesses. At the time of this pilot, relevant data was not yet accessible, however in future reports the contributions of new and young businesses to overall employment creation in Queensland will be included.

3.2 Startups

Beyond employment growth, studies by the OECD found that new and young businesses are also important for productivity growth and for introducing disruptive innovations to the market.[51] According to the Australian Innovation System Monitor, a small fraction of Australian startups drive the majority of net job creation, a pattern that is consistent across OECD economies.[52] These high growth startups show high value sales and profit performance (e.g. ‘unicorns’)[53], but may have lower labour productivity, compared to other surviving startups.

3.2.1 Startup and Entrepreneurship Trends

According to a study by the Office of Chief Economist, Australia and Queensland have a relatively high proportion of startups but between 2001 and 2013 there was a declining trend, similar to that in many other OECD countries. In parallel with the decline in the startup rate during this period, Australian startups’ share of gross job creation had fallen, from around 32 per cent to less than 15 per cent.[54] This study has not been updated to include the most recent micro business data; thus, it is difficult to know if this trend has changed in Australia.

In a longitudinal study of perspectives on Australian entrepreneurship, the Global Entrepreneurship Monitor (GEM) similarly reported downward trends in entrepreneurship, such as:

[51] Calvino, F., Criscuolo, C. and Menon, F. 2015. *Cross-country evidence on startup dynamics, OECD Science, Technology and Industry Policy Papers*, 2015/06, OECD Publishing, Paris. Calvino, F., Criscuolo, C. and Menon, F. 2016. *No country for young firms?: startup dynamics and national policies*. OECD Science, Technology and Industry Policy Papers, No. 29, OECD Publishing, Paris. OECD, 2020. Entrepreneurship at a glance highlights 2018. OECD Science, Technology and Industry Policy Papers, No. 29, OECD Publishing, Paris

[52] Department of Industry, Science, Energy and Resources, 2020. *Australian Innovation System Monitor 2021 March edition*. The Commonwealth of Australia

[53] A ‘unicorn’ company is a privately held startup company that is valued at more than $1 billion. It is a term used the investing community and was coined by venture capitalist Aileen Lee in 2013 to distinguish the rarity of such startup companies. Source: https://pitchbook.com/blog/what-is-a-unicorn

[54] Hendrickson, L., Bucifal, S., Balaguer, A. and Hansell, D., 2015. *The employment dynamics of Australian entrepreneurship*. Research Paper 4/2015. Department of Industry and Science and Australian Bureau of Statistics. Office of Chief Economist, Australian Government.

- Total Early-stage Entrepreneurial Activity (TEA)[55], in particular nascent entrepreneurship, has been in decline in Australia since 2014. Globally, Australia ranks around the middle, above countries like China and Germany, but below Israel, the United States of America and Canada.
- Queensland (10.6%) has the second lowest proportion of TEAs of states and territories. The Australian Capital Territory (15.9%), Northern Territory (13.8%) and Western Australia (12.9%) have the highest proportion of TEAs in the country.[56]

Evidence of entrepreneurial activity was generally positive pre-pandemic (2019), in areas such as Queenslanders' perception of business opportunities (44.8%) and whether they have the knowledge, skills and experience to undertake entrepreneurial activities (53%).

However, 52.1% of Queenslanders surveyed had a fear of failure in relation to entrepreneurial activities, lower than the Australian Capital Territory (59.1%), Western Australia (54.9%), Northern Territory (54.1%) and New South Wales (53.7%).[57]

3.2.2 Estimation of the Number of Startups

A Definition

Startup definitions are contentious, and measurement is challenging. It is recognised that different definitions are useful in a variety of contexts – program criteria, policy, research and macro-economic analysis.

Startup identification and measurement are evolving with data maturity and research in this field. Inconsistent definitions and methods used by all levels of government across jurisdictions, by the private sector and researchers has contributed to the difficulty in accurately measuring startups. Government program data on individual businesses often lack completeness. Private or commercial data provide more consistency, although data is generally derived from a small sample size and access is costly.

DTIS is working in coalition with other states and the federal Department of Industry, Science, Energy and Resources on the National Startup Data Project to develop a national approach to data collection and measurement of startups. This project proposes to pilot a startup measure and development of data infrastructure to collate data sources. This will enable stakeholders to access data for analysis to inform research, evaluation and policy making.

To enable objective jurisdictional comparisons, this document uses the OECD age-based definition of young firms and startups:[58]

- Startups: firms aged 0 to 2 years old
- Young firms: aged 0 to 5 years old

Government and superannuation entities have been excluded. By definition, startups will be a subset of the young firm population.

Age-based definitions are generally inclusive and, in this way, figures represent an upper ceiling of estimation. That is, of the young firms and startups quantified using the above criteria, a subset of these groups will be 'innovative' firms which can be identified using various markers for innovation performance. It is recognised that this age-based definition has limitations and may not reflect the 'lived experience' of startups or cohorts in government programs. See Appendix B for full details of the application of this definition using micro-business data.

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[55] Businesses in the process of starting a business or operating for 3.5 years or less at the time of the survey.

[56] Renando, C. & Moyle, C, 2021. *Global Entrepreneurship Monitor 2019: Australia Report*. Brisbane, Australia: Australian Centre for Entrepreneurship Research, Queensland University of Technology, p.35.

[57] Ibid, p.39.

[58] Criscuolo, C., P. Gal and C. Menon, 2014, *The Dynamics of Employment Growth: New Evidence from 18 Countries*, OECD Science, Technology and Industry Policy Papers, No. 14, OECD Publishing, Paris. http://dx.doi.org/10.1787/5jz417hj6hg6-en. This approach to quantifying startups is drawn from the OECD's *DynEmp* project which use firm level data sourced from national business registers. The authors assert that the national business registers provide the most comprehensive coverage of economic activity and business performance through the collection of firm entry, exits, employment and/ or turnover, tax, census and administrative data. Importantly, this type data allows comparisons between jurisdictions.

3.2.3 Queensland's Startups and Young Firms

Note: Some caution should be used when interpreting the estimated figure of startups provided in this report, as markers for innovation and entrepreneurship performance have not been applied. In future efforts, analysis of startup characteristics and performance could be included.

In Queensland one in ten businesses are startups.

Surveys have estimated Queensland startups to be about 20% of the business population:

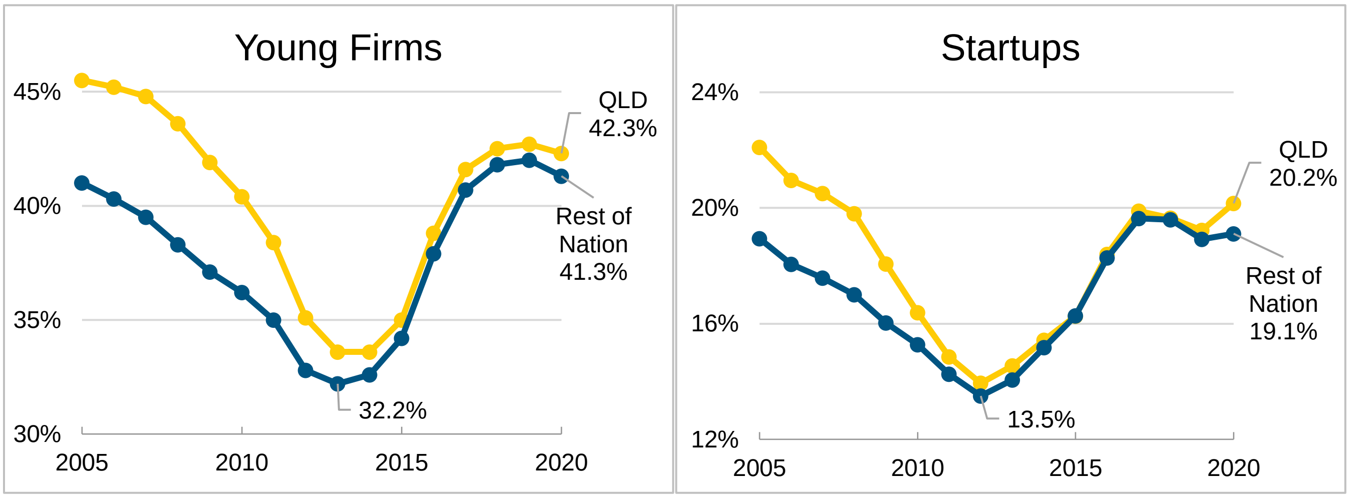
- In 2018, Startup Muster estimated that startups made up approximately 19.7% of the surveyed entrepreneurs or self-identified 319 founders.[59]
- In 2019, a report on the Massachusetts Institute of Technology (MIT) Regional Entrepreneurship Acceleration Program (REAP) panel survey estimated that there are 20% or 55-65,000 startups in Queensland.60

This correlates with analysis of the LABii data vault, which found that in 2020, 20% of businesses in Queensland fit the startup criteria (Figure 23). Compared with other states and territories, Queensland had the fourth highest proportion of startups after Australian Capital Territory, Northern Territory and Victoria.

Around 42% of businesses in Queensland fit the young firm criteria. In general, between 2005 and 2020, Queensland has a higher proportion of young firms than the rest of the country.

Since 2012, trends in young firms and startups in Queensland have been similar to Rest of Nation.

Figure 23: Estimate of Young Firms and Startups as a Proportion of Live Businesses 2005 - 2020



Source: Longitudinal Australian Business Integrated Intelligence (LABii) DataVault - QUT

Queensland has a higher proportion of startups in knowledge-intensive industries than the Rest of the Nation.

Trade and Investment Queensland (TIQ) has defined the value of knowledge-intensive products as depending on the skills that went into producing them, rather than the actual cost of the components.[61]

[59] Startup Muster https://startupmuster.com/

[60] Moyle, Char-lee, Pandey, Vibhor, Renando, Chad, Barrett, Rowena, & Sharma, Arun, 2019. *Queensland connects: Accelerating Queensland's innovation-driven entrepreneurs*. Australian Centre for Entrepreneurship Research, QUT Business School, Australia. Startup Muster survey (2018) respondents include 1,617 startup founders, of which 319 were located in Queensland. MIT REAP Panel Survey was conducted in 2018 with 1,018 Queensland residents aged 18 years and over.

[61] Office of the Queensland Chief Scientist, 2015. Knowledge Intensive Services - Growing Queensland's knowledge intensive services sector through science, research and innovation, Brisbane, Australia.

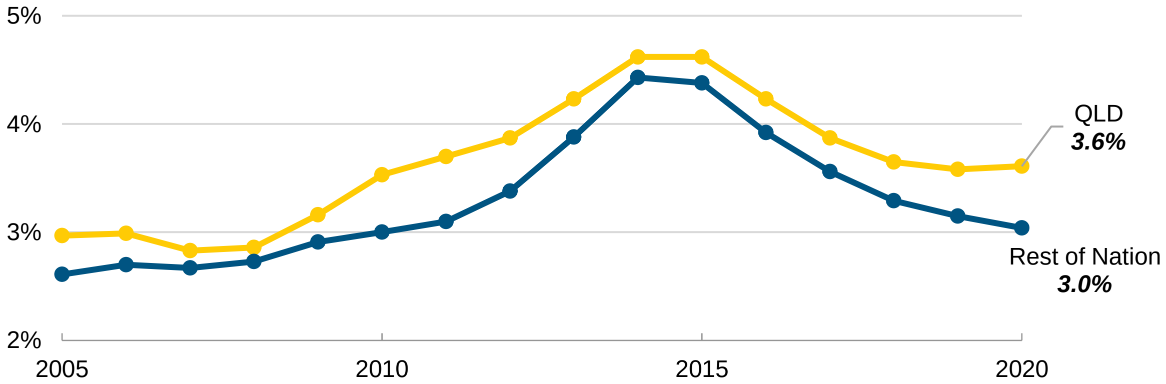
According to the OECD, knowledge-based industries are those which are relatively intensive in their inputs of technology and human capital. Practically, these definitions are industry code based.

Queensland consistently has a higher proportion of startups in knowledge-intensive industries than the rest of the nation, with an increasing divergence occurring since 2018 (Figure 24).

Around 1 in 140 businesses in Queensland are startups in knowledge-intensive industries. This is marginally higher than the rest of nation (around 1 in 170).

In 2020, it is estimated that of the 351,000 Queensland startups, 12,700 (or 3.6%) were in knowledge-intensive industries (Figure 24).

Figure 24: Proportion of Startups in Queensland knowledge-intensive Industries, 2005- 2020



Source: Longitudinal Australian Business Integrated Intelligence (LABii) DataVault – QUT. Knowledge-intensive Industries definition supplied by Trade Investment Queensland.

3.3 Digital Readiness

Inadequate human capability and infrastructure are barriers to digital readiness. Queensland may be hampered by a lack of capability and technology-oriented businesses to achieve high growth.

Digital technology underpins all aspects of the economy and society. Importantly it creates opportunities for Queensland businesses and enables productivity. According to a longitudinal study by the Chamber of Commerce and Industry Queensland (CCIQ) on Queensland business digital readiness in 2021 (Table 11, Table 12, and Table 13):[62]

Table 11 Queensland Chamber of Commerce and Industry survey results on business digital readiness, 2022 and 2021

2020	2021	Change
78% of businesses have a Facebook profile. However, 26.6% of businesses do not know how many visitors they have on their website monthly.	79.2% of businesses have a Facebook profile. However, 28.1% of businesses do not know how many visitors they have on their website monthly.	1.2% increase in Facebook profile. More (1.5% increase) businesses are unaware of the unique visitors to their website than the previous year.
78% of businesses are optimistic about using technology, this has dropped from 90% since 2016.	69% of businesses are optimistic about using technology.	9% decrease in optimistic outlook.

[62] Chamber of Commerce and Industry Queensland, *CCIQ 2020 Digital Readiness Report* and *CCIQ 2021 Digital Readiness Report*: *How do Queensland businesses use technology?* Survey sample size: 343 (2020) and 404 (2021) business respondents.

2020	2021	Change
95% of businesses in Qld have a website but one in four business owners are not aware of the effectiveness of their online presence.	93.1% of businesses in Qld have a website which is the top digital asset.	1.9% decrease in website as the top digital asset. In 2021, top digital assets following websites, in order: Facebook (79.2%); LinkedIn (50.1%); Instagram (42.4%); YouTube (20.8%); Twitter (17.9%); Pinterest (4.5%), None (25%)
47% of Queensland businesses believe that the state government could improve support to businesses to adjust to digital change.	Not reported	
33% of Queensland businesses believe that that the state government could improve the ease of doing business with its agencies using digital technologies.	Not reported	

Faster internet speeds seem to be driving Queensland businesses to do more business in the cloud.

Table 12 Queensland Chamber of Commerce and Industry survey results on connectivity, 2022 and 2021

2020	2021	Change
23% were already fully cloud-based before this current survey.	26% were already fully cloud-based before this current survey.	3% increase in use of applications in the cloud.
63.3% of businesses reported using a cloud-based backup of their data.	70.1% of businesses reported using a cloud-based backup of their data	6.8% increase in cloud-based data backup.
45% of businesses thought their internet was better than the previous year.	27% of businesses thought their internet was better than the previous year.	18% decrease in experience of connectivity.

Queensland businesses are most concerned about the following issues.

Table 13 Queensland Chamber of Commerce and Industry survey results on perspectives on priority issues for businesses, 2022 and 2021

2020	2021	Change
Internet reliability (48%).	Internet reliability (38.5%).	9.5% improvement in perceived reliability.
The cost of IT (39%).	The cost of IT (31.9%).	7.1% improvement in perceived cost of IT.
Lack of digital and IT skills (45%).	Lack of digital and IT skills (53.1%).	8.1% increase in concern.
The rapid technology change (31%) negatively impacting on their business.	The rapid technology change (39.6%) negatively impacting on their business.	8.6% increase in concern.
On a scale of 1 to 5 businesses that rate their digital readiness at ‘5’ (ready) is 8%.	On a scale of 1 to 5 businesses that rate their digital readiness at ‘5’ (ready) is 3.5%.	4.5% decline in perceived digital readiness.

It is recognised that digital connectivity is also barrier to regional economic development. Another study on innovation in Goondiwindi identified that the lack of digital connectivity, coupled with low density of entrepreneurial support and limited specialist service providers, posed a challenge for building local innovation capabilities.[63]

According to a 2020 report by the Australian Computer Society (ASC) the medium-term forecast for the growth rate of the technology workforce in Australia is 3% over the next five years.[64]

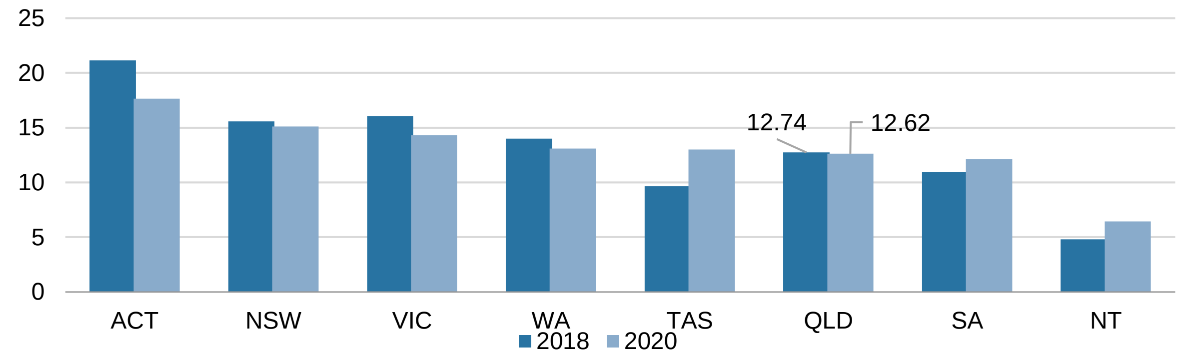
Despite this broadly positive outlook, the ASC reported that Australia is not on track to being a digital leader, currently ranking seventh out of 16 countries in the ranking system.[65] This finding from the ASC report is corroborated by the negative trend in student participation in Information Processing Technology and Information Technology Systems subjects in Queensland schools.

In 2020, Queensland was ranked sixth (12.62 out of 25) in CISCO's Digital Readiness Index, with the Australian Capital Territory ranked first (17.64 out of 25) in the country in 2020 (Figure 25). This Index assesses seven factors to arrive at a digital readiness score: Technology infrastructure; Technology adoption; Human capital; Basic human needs; Ease of doing business; Business growth and government investment and Startup environment.[66]

In this most recent ranking, Queensland gains from 2018 to 2020 include:[67]

- *Basic Needs* from 3.37 to 3.60. This component is defined as 'basic needs for a population to survive and thrive'.
- *Technology Adoption*, from 1.16 to 1.93, also rising from sixth to third place in *Technology Adoption* in Australia. This component is defined as 'demand for digital products/ services' among the population.
- *Startup Environment* from 1.48 to 1.57. This component is defined as an 'environment which fosters innovation within a community'.

Figure 25: Cisco Digital Readiness Index 2018 and 2020



Source: CISCO Australian Digital Readiness Index 2018, and 2020

3.4 Investment Attraction

Access to adequate capital at the appropriate time in the development process is critical to growing innovative businesses across Australia and Queensland.

Financing for innovative projects in new businesses is available from several sources, including friends and family, 'angel' investors, banks, governments, and venture capital firms. Each source offers

[63] Renando.C and Lyons. B., (n.d). *Goondiwindi AgTech Innovation Hub Feasibility Study and Business Case*. Rural Economies, Centre of Excellence and Startup Status.
[64] Deloitte, 2020. ACS Australia's digital pulse: unlocking the potential of Australia's technology workforce. Australian Computer Society.
[65] Ibid, p.1.
[66] CISCO uses these seven components to score each area to derive an aggregate score of 25, which represents aspects of digital readiness. Source: https://www.cisco.com/c/dam/m/en_au/digital-readiness/pdfs/cisco-wp-driAustralia2020.pdf
[67] CISCO, 2020. Australian Digital Readiness Index 2020: Building societal resilience through digital investment, p. 14.

advantages and disadvantages to the business. Informal financing, such as personal credit cards, friends, family, and angel investors, can offer limited capital and is an infrequent funding source for the long term.

The Lerner report[68] asserted that the role of government intervention in supporting innovation and venture capital is on two fronts. First, venture capital, the primary funding source for high impact entrepreneurship can lead to an industry with increasing returns to scale. Second, many of the levers necessary for a venture capital and innovation system to thrive are under government's control. Some of these include a tax system that encourages long-term investment; pension regulations that encourage these funds to invest; and stock market regulations that allow exits via stock market listings as well as mergers and acquisitions.

3.4.1 Startup Finance

Access to adequate capital is a significant hurdle to growing innovative businesses across Australia and OECD nations.[69] Of Australia's $12 billion venture capital and later stage private equity investment in the year 2018-19, 23% ($2.8 billion) was for investment in innovative businesses that are at the pre-seed, seed, startup or early expansion stages.[70]

At the time of data collection, investment by business age comprised of:

- 12% ($1.5 billion) of innovative businesses that are less than five years old
- 21% ($2.6 billion) of businesses aged five to ten years
- 67% ($8 billion) of businesses aged over 10 years.

Australia's startup funding environment is strong, with more than $10 billion in funding received by startups in 2021.[71] According to a recent report, more international and local investors are actively participating than ever before, and investors are expecting startup funding to increase in 2022.[72] Other trends identified in this report include:

- alternative capital (such as venture debt) and new financing models (such as revenue-based financing) have become increasingly attractive as startups look to stay private for longer
- gender disparity appears to be increasing, as the total capital invested in female-founded startups fell in 2021 compared to 2020.

Female Founders

In recent years, the study of women's entrepreneurship has contributed to understanding factors that explain the barriers faced by women in undertaking an entrepreneurial career, with one of the most significant being access to funding. [73]

According to Techboard over the four years from 2018 to 2021 there has been a general trend upward in the proportion of overall and private funding secured by female-founded companies with mixed gender teams and solely female founded companies in Australia.[74] Solely female-founded companies only secured 4% of all funding and 19.7% was secured by companies with a mixed gender founding team.

In terms of distribution of all types of funding for female-founded companies, Victoria leads the way (34.7%) followed by South Australia (29.7%), Queensland (15.5%) and New South Wales (15.2 %).

The top three investors in Queensland's solely female-founded companies by number of deals are Startmate, Brisbane Angels and Artesian Ventures.

At the time of writing this report, data on startup finance was limited to the aggregate level. In future analysis on this topic, the team will endeavour to present state level results.

[68] Lerner. J, Speen. A, Bosilijevac. V, Tighe. J and Leamon. A, 2014. *Queensland's innovation ecosystem and recommendations for future action* (unpublished).
[69] Ibid, p.42
[70] Australian Bureau of Statistics, *Venture Capital and Later Stage Private Equity*, Australia, 2018-19 Cat. 5678.0 Table 9.
[71] Cut Through Venture and Folklore, 2021. The State of Australian Startup Funding 2021.
[72] Ibid.
[73] Cardella GM, Hernández-Sánchez BR and Sánchez-García JC, 2020, *Women Entrepreneurship: A Systematic Review to Outline the Boundaries of Scientific Literature*. Front. Psychol. 11:1557. https://doi.org/10.3389/fpsyg.2020.01557
[74] Techboard, 2021. *Female founder funding report FY2018 - FY2021*. Report Downloads - Techboard

3.4.2 Venture Capital and Later Stage Private Equity

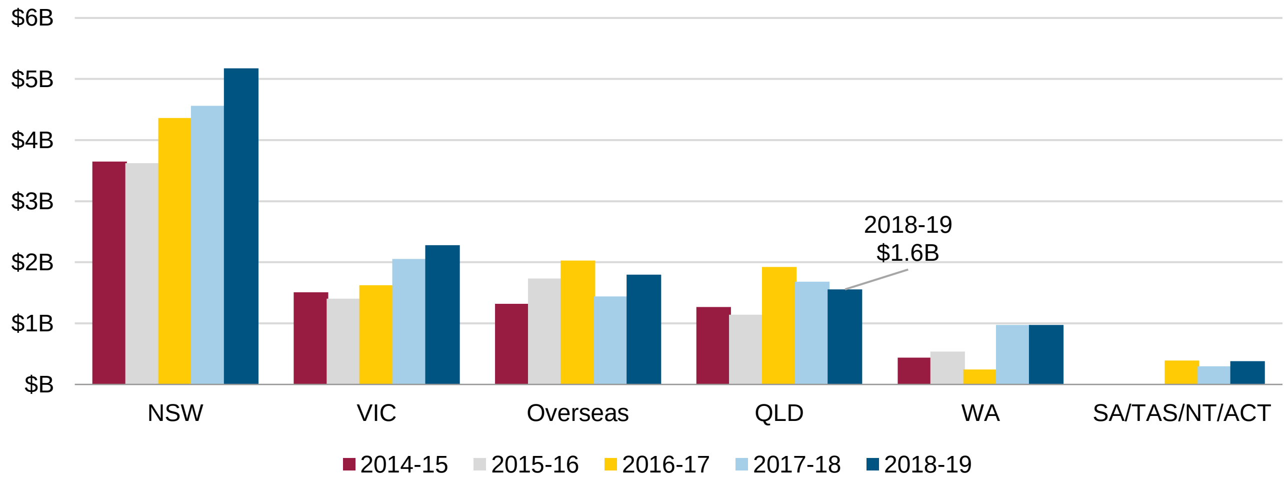
Venture capital has an important role in financing the launch, early development and expansion of an innovative and high growth potential business. These businesses may have difficulty accessing traditional sources of capital due to their higher risk profile and latterly the impact of COVID-19 on the investment market.

The dollar value of venture capital investment in Australia peaked in 2007-08 with $901 million invested and declined in 2012-13 ($266 million).[75] More recently, Australia's venture capital and later stage private equity investment has been trending up, reaching $12 billion in 2018-19, an increase of 11% on the previous year 2017-18.[76]

Queensland lags behind NSW's high trend growth in venture capital and late-stage private equity investment by location of investee company head office.

In Queensland, the value in dollar terms was $1.6 billion in 2018-19, a decline from $1.9 billion in 2016-17 (Figure 26).

Figure 26: Venture Capital and Later Stage Private Equity Investment by Investee Business Headquarter Location, 2014-15 – 2018-19



Source: Australian Bureau of Statistics (ABS), Venture Capital and Later Stage Private Equity, Australia, 2018-19 (cat: 5678.0)

3.4.3 Crunchbase Investment Data

Crunchbase is one of many companies which aggregate innovation-related data, including: investor details, deals, startups, etc. Data is sourced through a variety of methods including investment firms, Crunchbase users and web scraping. As such, data is plentiful, but not always clean.

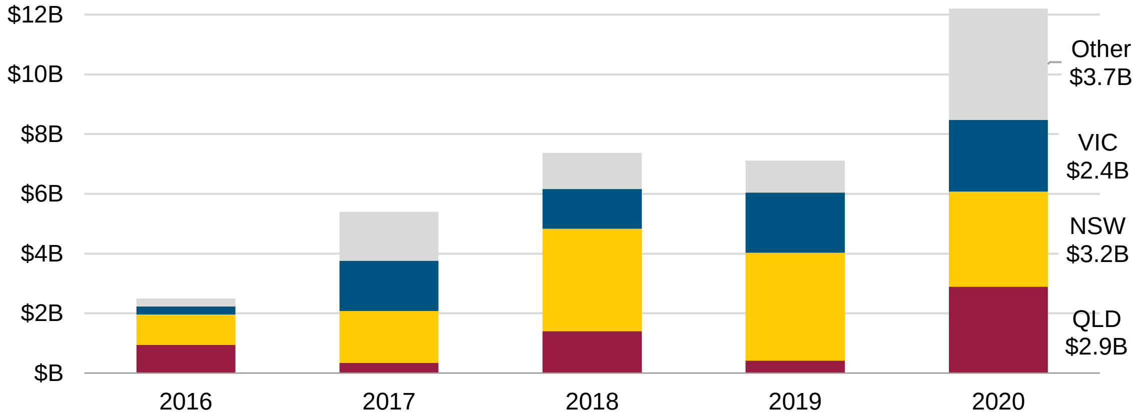
Findings from analysis of Crunchbase data include:

- In 2020, Queensland attracted almost a quarter (USD$2.9 billion) of the total investment in Australia (Figure 27).
- New South Wales (USD$3.2 billion) consistently attracts the most investment of any state or territory.[77]
- Over half of investors within Australia are based in New South Wales (Figure 28).

[75] Department of Industry, Science, Energy and Resources, 2020. *Australian Innovation System Monitor 2021 March edition*. The Commonwealth of Australia, p.41.
[76] Australian Bureau of Statistics, Venture Capital and Later Stage Private Equity, Australia Cat. 5678.0 2018-19.
[77] Value is recorded in USD in Crunchbase data.

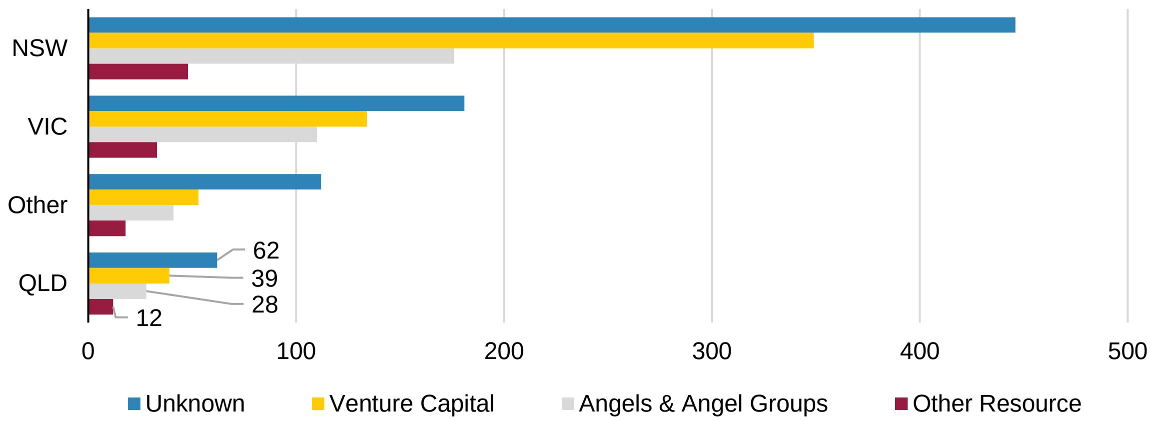
- VC and Angels/Angel Groups are the most common investor types, however there is a large gap of knowledge in this space (43 % of this data is 'unknown').

Figure 27: Value of Investment (USD$) 2016-2020 by States and Territories



Source: Crunchbase as at May 2021

Figure 28: Count of Australian Investors, May 2021 by States and Territories



Source: Crunchbase as at May 2021

4 Innovation Outputs

According to the recent Global Innovation Index (2020) report, a successful innovation system balances the push for knowledge creation, exploration and investment (innovation inputs) with the pull for ideas and technologies towards application, scale and impact (innovation outputs).[78]

Innovation outputs are the result of innovative activities within the economy. Measures that quantify innovation outputs remain scarce. For instance, there are no statistics on the quantity of innovative activities (number of new products, processes or services) and current measures do not comprehensively capture the breadth of innovation outputs and outcomes produced across sectors.

Consistent with national and global trends (as at 2020), based on available data, productivity growth appears to have slowed in Queensland.[79] Key factors contributing to the slowdown include: declining investment levels; declining productivity in construction industry; slowing output in the mining sector; and natural disasters. As the second year of the global pandemic, 2021 has presented opportunities for recovery and new global challenges which provide a backdrop to Queensland's innovation system development and growth.

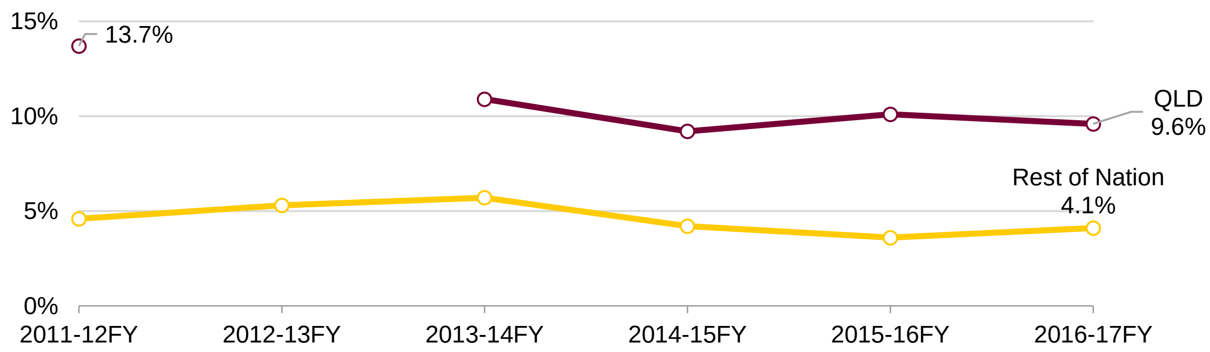
This section outlines Queensland innovation outputs at the system level, in particular knowledge-intensive exports and knowledge creation.

4.1 Exports

Although productivity growth has slowed in Queensland, the state recorded stronger growth than the rest of Australia over the last two decades.

Queensland has consistently relied upon exports much more than Rest of Nation (Figure 29) with export sales making up 9.6% of the state's turnover.

Figure 29: Export Sales as a Proportion of Turnover, QLD and Rest of Nation, 2011-12 – 2016-17FY



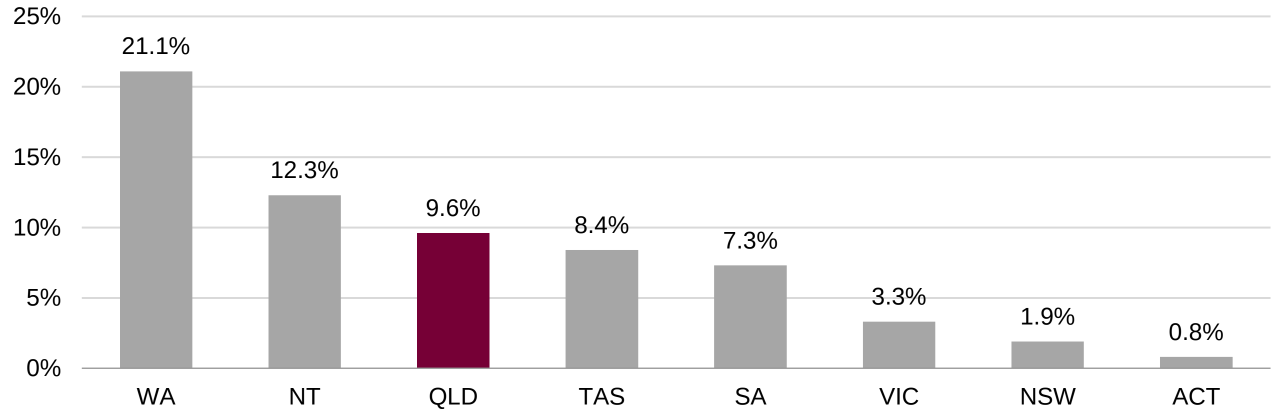
Missing data due to confidentiality protection as required by ABS.

Source: Australian Bureau of Statistics 2001-2017, Business Longitudinal Analysis Data Environment (BLADE), (2011-12 to 2016-17FY). Detailed Microdata, DataLab. Findings based on the use of ABS Microdata.

[78] Cornell University, INSEAD and WIPO, 2020. *The Global Innovation Index 2020: Who will finance innovation?.* Ithaca, Fonthainebleau and Geneva.
[79] Queensland Productivity Commission, 2020. *Queensland Productivity Update 2018-19*, Research Paper.

By comparison, in 2016-17, Western Australia recorded 21.1% of its turnover in exports, suggesting a far higher reliance (Figure 30). Victoria and New South Wales have a lower reliance on exports, 3.3% and 1.9% respectively.

Figure 30: Export Sales as a Proportion of Turnover, by States and Territories, 2016-17



Source: Australian Bureau of Statistics 2001-2017, Business Longitudinal Analysis Data Environment (BLADE), (2011-12 to 2016-17FY). Detailed Microdata, DataLab. Findings based on the use of ABS Microdata.

Queensland maintains a high reliance on mining and manufacturing for its export industry.

Of Queensland's exports in 2018-19, the mining industry made up 77% (~$67.1 billion) while manufacturing made up 13% (~$11.4 billion), leaving just 10% of exports originating from other industries.[80]

4.2 Knowledge-intensive Services Exports

Over a 20-year period, the value of Queensland's knowledge-intensive services exports has increased steadily.

Knowledge-intensive activities are key drivers of growth, future job creation and prosperity in Queensland's economy. Knowledge-intensive trade relies on knowledge-based industries which draw heavily on technology, science, innovation and human capital inputs.

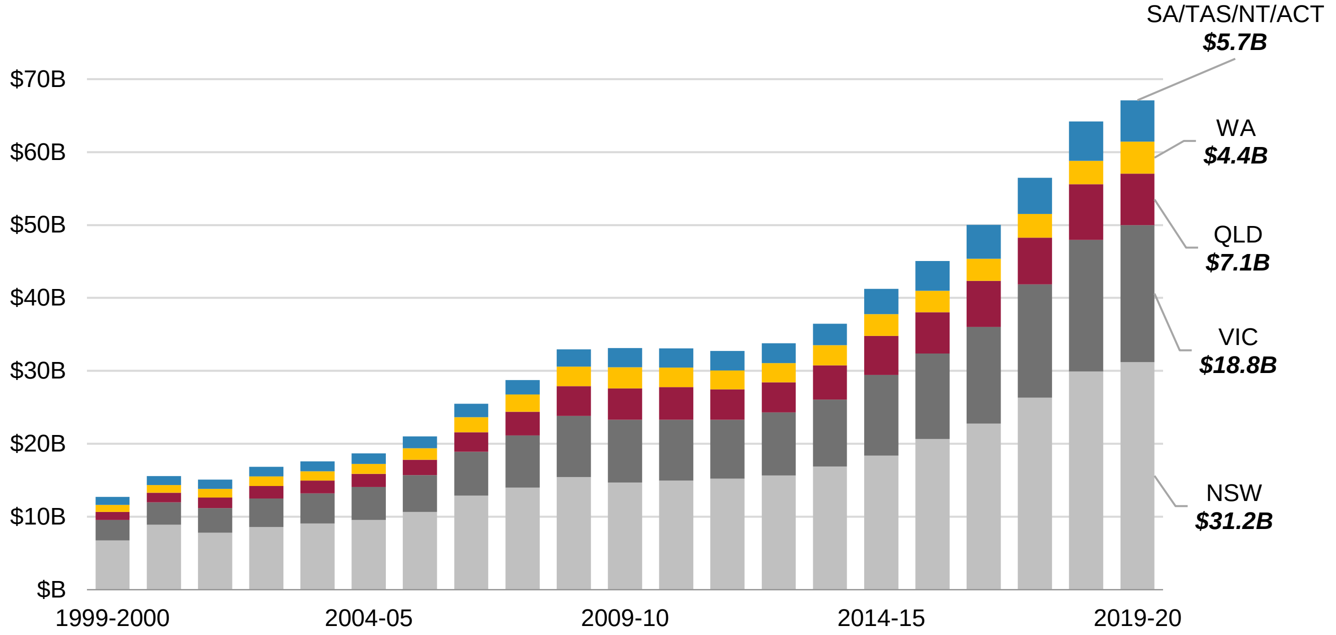
Considering the export value of services from businesses in knowledge-intensive industries, over a 20-year period, the value of Queensland's knowledge-intensive services exports has increased, up almost 550%, and outpacing Rest of Nation (up 320%).

As a proportion of Australia's knowledge-intensive exports:

- in 2019-20, Queensland's contribution is third highest (10.5%), behind New South Wales (46.5%) and Victoria (28.0%) (Figure 31).
- Queensland's contribution peaked in 2010-11 at 13.5% (down to 10.5% in 2019-20).

[80] Australian Bureau of Statistics, Characteristics of Australian Exporters, 2018-19, Australia Cat. 5368.0.55.006.

Figure 31: Value of knowledge-intensive Services Export, 1999-20 to 2019-20 by States and Territories



Source: Australian Bureau of Statistics (ABS), International Trade: Supplementary Information (cat: 5368.0.55.003). Knowledge-Intensive Industries definition supplied by Trade Investment Queensland.

4.3 Knowledge Creation

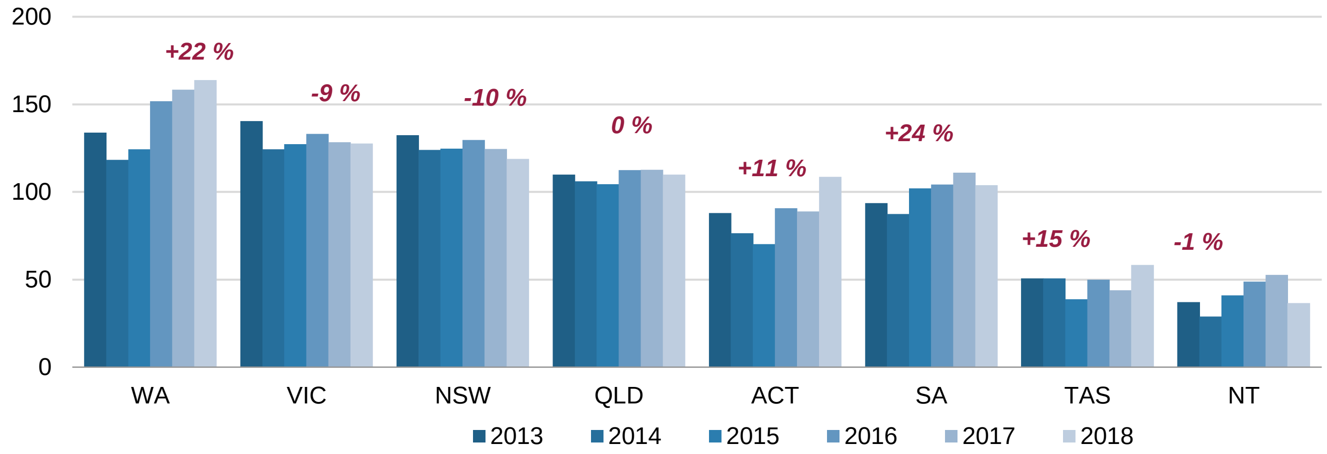
The extent to which innovative businesses collaborate with other stakeholders is a measure of connectedness between different parts of the innovation system. Collaboration, an innovation input, is any arrangement where organisations work together for mutual benefit and share some of the technical and commercial risks.

The result of innovation collaboration is knowledge creation which has application and potential to scale for impact. This section provides an overview of patent applications in Queensland as a proxy for knowledge creation. A recent report by IP Australia found that collaborative grants have a higher impact on boosting all types of patent applications than non-collaborative ones.[81]

[81] IP Australia 2018. *IP Report 2018: Collaborative research grants lead to better IP outcomes*. https://www.ipaustralia.gov.au/ip-report-2018/research-grants

Patent applications per million residents has remained flat in Queensland in the six years to 2018 (Figure 32). The Australian Capital Territory (24%), Western Australia (22%) and Tasmania (15%) have had increased patent applications over the last six years to 2018.

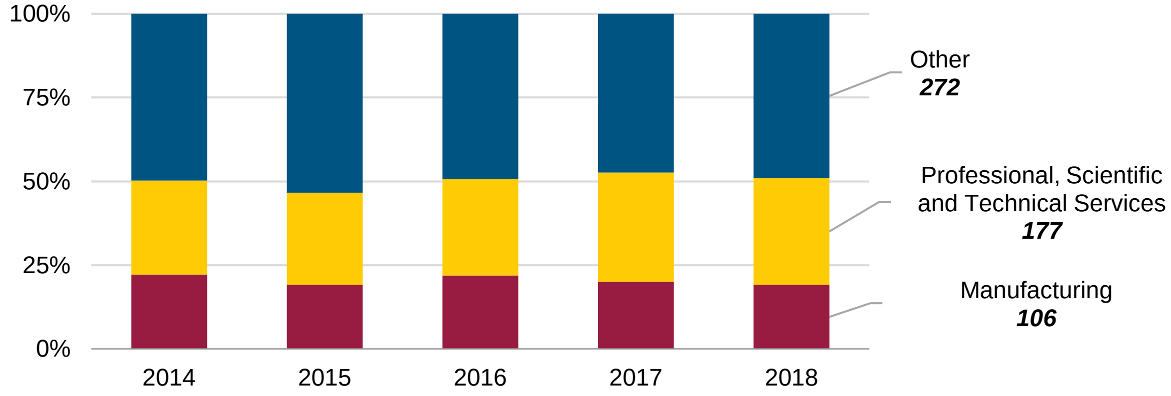
Figure 32 Number of Patent Applications per Million Residents, 2013- 2018 by States and Territories



Source: Longitudinal Australian Business Integrated Intelligence (LABii) DataVault - QUT

Over half of Queensland patent applications are in *Professional, Scientific and Technical Services* and *Manufacturing* industries (Figure 33). In 2018, this was 32% (177 applications) and 19% (106 applications) respectively.

Figure 33: Number of Patent Applications by Industry Classifications of QLD Businesses, 2014 - 2018



Source: Longitudinal Australian Business Integrated Intelligence (LABii) DataVault - QUT

5 COVID-19 Impact on Innovation and Business Sentiment

Many of the quantitative data are pre-COVID-19, and thus this report presents results and offers interpretations of innovation-related insights prior to the pandemic. The real impacts of COVID-19 and the government measures to capture this will not show up in the data for some time. Where data and information are available at the state level, the team has endeavoured to include in this report.

5.1 National Trends

Business innovation in Australia — as measured by the National Australia Bank's Business Innovation Index — has fallen significantly in the wake of the COVID-19 pandemic. Widespread supply-chain and cash flow disruptions forced business closures, and labour shedding has impaired businesses' ability to do things more quickly or more cost efficiently in 2020. However, the challenges of the COVID-19 crisis have encouraged businesses to do things differently and this appears to have contributed to better than expected employment figures in 2021.[82]

According to Atlassian co-founder Scott Farquhar, Australia has been great in producing 'junior talent' and the challenge going forward is mature local talent to maintain high value jobs in the economy. Another observation is that with increased market connectivity, startups need more capital to launch and expand than they did 20 years ago.[83]

The 2021 Intergenerational Report projected the impact of the pandemic on economic activity for the next 40 years. The policy implication for federal and state governments includes increasing workforce participation, productivity through tax incentives and greater business investment.[84]

5.2 Queensland Business Sentiment

According to a survey by the CCIQ, Queensland businesses have diversified their operation whilst leveraging economic activity that flowed from Federal and State stimulus.[85] During the March 2021 quarter, business sentiment appeared to have improved since 2020. However, by December 2021 quarter business confidence had declined to the lowest level since September 2020. The decline in Queensland business confidence is reflective of the compounding impacts of labour shortages, supply chain disruptions and lower consumer spending.[86]

The December 2021 pulse survey conducted by the CCIQ identified that Queensland businesses are uncertain in their outlook for 2022 and business viability due to the following factors:[87]

- staff shortages due to COVID-19 self-isolation requirements and vaccination requirements for employees
- material shortages and supply chain disruptions that are leading to higher business input costs
- absence of financial support for small businesses affected by the pandemic requirements
- lagging impact of interstate and international border restrictions
- rising insurance, fuel and other business input costs
- continuing trade restrictions with China.

[82] Office of Chief Economist, 2021. *Australian Innovation System Monitor March 2021 edition*. Department of Industry, Science, Energy and Resources, Australian Government, Canberra.
[83] O'Dowd. C, 2021, *Rally cry for tech industry growth*. The Australian, Australia, 7 May 2021, p.16.
[84] Hutchens. G, 2021. *The first intergenerational report helped spark Australia's latest immigration boom. What will this one bring?*. ABC, 28 June: https://www.abc.net.au/news/2021-06-28/intergenerational-report-delivered-what-will-it-mean/100248344
[85] Chamber of Commerce and Industry Queensland, 2021. CCIQ Pulse Survey of Business Conditions, March Quarter 2021.
[86] Chamber of Commerce and Industry Queensland, 2021. CCIQ Pulse Survey of Business Conditions, December Quarter 2021.
[87] Ibid.

6 Conclusion

The aim of this pilot is to progress the measurement of innovation in Queensland. To this end it has:

- demonstrated high-level findings from analysis of selected metrics and datasets
- generated policy discussion and questions about innovation in Queensland and evidence for performance.

Data and metrics selected for this pilot capture a broad picture of innovation Queensland, one which relies on knowledge inputs for the purpose of economic and productivity growth. The state of innovation, at this point in time, is summarised below.

Human capability

While there has been an increase in students studying science and maths subjects in the last eight years, the decline in students studying IT could affect the supply of future workers in technology. Male student participation continues to dominate in advanced maths, however increasing female student participation in this subject has been closing the gap over time.

Although there is an incremental growth in female students studying IT and physics subjects, female participation remains significantly under-represented in these subjects. This is likely to affect the supply of female enrolments in higher education courses requiring foundational knowledge in maths, physics and technology.

Although the number of female enrolments and completions in STEM courses in higher education have increased incrementally over the nine-year period to 2019. The trend for year-on-year change in female enrolment and completion is on a downward trend suggesting that female STEM graduation rates are declining over time. First Nations student participation in STEM courses has increased significantly over the nine-year period to 2019. Similar to females, First Nations students remain under-represented in STEM courses.

While Queensland's knowledge workforce has increased over the past two decades, it lags behind other states like South Australia, New South Wales and Victoria. STEM participation in Queensland universities needs to increase if the state's workforce is to be equipped for the jobs of the future and for the state to remain nationally and internationally competitive.

Research and Development

Queensland is home to high quality researchers and universities. The state is well placed to be a leader in innovation, science and technology. Universities have continued to maintain their competitive advantage in attracting research funding, education and knowledge creation.

Spending on R&D across sectors (business, higher education and government) over time, has increased. Queensland is making significant gains in Government Expenditure on R&D (GOVERD) in terms of spending increases over time. Queensland Government investment to support research and development trended up slightly over a 16-year period and peaked in 2010-11. Queensland lags behind New South Wales and Victoria in the rate of spending increase on Higher Education Expenditure on R&D (HERD).

Innovation environment

Economic conditions in Queensland are broadly supportive of business creation. In Queensland one in ten businesses are startups. Queensland has a higher proportion of startups in knowledge-intensive industries than the Rest of the Nation.

Inadequate human capability and infrastructure are barriers to digital readiness. Queensland may be hampered by barriers in human capability and technology-oriented businesses to achieve high growth.

Investment attraction

Queensland follows New South Wales' high growth in venture capital and late-stage private equity investment by location of investee company head office, overtaking Victoria in 2016. In 2020, Queensland attracted almost a quarter (USD$2.9 billion) of the total investment in Australia.

Innovation outputs

Although productivity growth (as at 2020) slowed in Queensland, the state recorded stronger growth than the rest of Australia over the last two decades. Over a 20-year period, the value of Queensland's knowledge-intensive services exports has increased steadily. However, patent applications per million residents have remained flat in Queensland in the last six years to 2018. Other metrics are required to adequately understand innovation outputs and outcomes in the state.

Demonstrated Use of Existing Databases

The pilot demonstrated that microdata, government data and market data can be acquired and analysed by the team. Other factors which have enabled the team to largely deliver a successful phase one include:

- Use of quality and confidential data under strong access controls
- A multi-disciplinary team with the appropriate mix of skills in quantitative and qualitative analysis
- A supportive leadership environment which provides guidance, direction and technical autonomy.

Next steps

The SOI pilot has aimed for measurement progress rather than perfection, and in this way there is less emphasis in this report on the 'best' metrics. In Phase Two of the project, an innovation measurement framework will be developed through consultation to identify relevant metrics and a wider range of data sources such as those in Table 14.

The intent of the SOI project is to develop rich data and insights to support evidence-based policy making and inform priority actions. Policy development to address challenges and strengthen innovation and entrepreneurship in the state is the purview of many agencies, including DTIS.

Table 14 ABS BLADE and MADIP core datasets

Dataset	Data Items
BLADE	ABS Business Register ABS survey data: • Business Characteristics Survey • Economic Activity Survey (imports and exports) • R&D Government administration data: • ATO (BAS, BIT, PAYG) • Federal government program data • IP Australia data
MADIP	• Census • Health • Education • Higher education and VET • Migration

Appendices

Appendix A: Definitions

The following definitions of terms commonly referred to in this document have been sourced from:

- Australian Bureau of Statistics (ABS)
- Australian Government Department of Industry, Science, Energy and Resources
- Organisation for Economic Co-operation and Development (OECD)

Term	Definition
Business expenditure on R&D	Business expenditure on R&D (BERD) represents the component of gross expenditure on R&D (GERD) incurred by units belonging to the Business enterprise sector. It is the measure of intramural R&D expenditures within the Business enterprise sector during a specific reference period.
Collaboration	The Oslo Manual 2018 defines collaboration as requiring co-ordinated activity across different parties to address a jointly defined problem, with all partners contributing. It requires the explicit definition of common objectives and it may include agreement over the distribution of inputs, risks and potential benefits. Collaboration can create new knowledge, but it does not need to result in an innovation. These interactions can consist of informal contacts and information flows, or more formal collaboration on innovation projects. Collaboration relies on openness and knowledge sharing but also some level of focus and accountability on the part of the business organisations.
Entrepreneurship	Entrepreneurship is the capacity and willingness to develop, organise and manage a new business venture along with risks in order to make a profit. Entrepreneurial spirit is characterised by innovation and risk-taking. Despite definitional differences it is generally agreed that entrepreneurship is both a driving force of and a challenge for young startups that lack funds, human capital and relevant experience. The inclusion of entrepreneurship in this report is due to the role of entrepreneurial skills required to commercialise innovation and find the right market.
Government expenditure on R&D (GovERD)	Government expenditure on R&D (GovERD) represents the component of gross expenditure on R&D (GERD) incurred by units belonging to the Government sector. It is the measure of expenditures on intramural R&D within the Government sector during a specific reference period.
Gross Domestic Product (GDP)	Gross Domestic Product (GDP) is the total market value of goods and services produced in Australia within a given period after deducting the cost of goods and services used up in the process of production but before deducting allowances for the consumption of fixed capital. GDP, as here defined, is at market prices. It is equivalent to gross national expenditure plus exports of goods and services less imports of goods and services.

Gross expenditure on R&D (GERD)	Gross domestic expenditure on R&D (GERD) is total intramural expenditure on R&D performed in the national territory during a specific reference period. GERD represents the total expenditure devoted to R&D by the business, government, higher education and private non-profit sectors during a specific reference period.
Higher education expenditure on R&D (HERD)	Higher education expenditure on R&D (HERD) represents the component of gross expenditure on R&D (GERD) incurred by units belonging to the higher education sector. It is the measure of intramural R&D expenditures within the higher education sector during a specific period.
Innovation	In this document innovation is defined as the implementation of a new or significantly improved product (good or service) or process, or a new organisational method in business practices, workplace organisation or external relations using technology or science. The latest version of Oslo Manual (Oslo Manual 2018) defined innovation as a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process).
Knowledge economy	The knowledge economy is a system of production and consumption that is based on intellectual capital. It is an economy in which growth is dependent on the quantity, quality, and accessibility of data and information, which can be used in various fields to generate economic value.
Later Stage Private Equity (ABS definition)	Later Stage Private Equity (LSPE) is defined as investment in companies in the late stage of expansion, turnaround and buy-out or sale stage of investment. The risks are high and investors have a divestment strategy with the intended return on investment mainly in the form of capital gains (rather than long-term investment involving regular income streams).
Nascent entrepreneurs	Nascent entrepreneurs are people who are engaged in creating new ventures by committing time and resources.
Organisation for Economic Co-operation and Development (OECD)	Organisation for Economic Co-operation and Development (OECD) is a group of countries working towards common problems of increasing economic growth, welfare and social problems. The list is comprised of Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Korea, Latvia, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States.
OECD Oslo Manual	The Oslo Manual provides guidelines for collecting and interpreting innovation data.
Research and Development (R&D)	Research and experimental development (R&D) comprises creative work undertaken on a systematic basis to increase the stock of knowledge, including knowledge of humankind, culture and society, and the use of this stock of knowledge to devise new applications. The term R&D covers three activities: basic research, applied research and experimental development. Basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular

	application or use in view. Applied research is also original investigation undertaken to acquire new knowledge but directed primarily towards a specific practical aim or objective. Experimental development is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.
Venture Capital (ABS definition)	Venture Capital (VC) is defined as high risk private equity capital for typically new, innovative or fast growing unlisted companies in the pre-seed, seed, startup or early expansion stage. A venture capital investment is usually a short to medium-term investment with a divestment strategy with the intended return on investment mainly in the form of capital gains (rather than long-term investment involving regular income streams).

Appendix B: A comparison of Young Firm and Startup Estimation Methodology

Over the years, many organisations involved within the innovation ecosystem have contributed their own definitions to the term "*startups*". Although definitions can be relatively simple to develop, they can be difficult to apply in practice. Consider these examples:

- "a company… searching for a repeatable, scalable and innovative business model or product." – National Startup Working Group, 2020, Conceptual Definitions
- "a technology-enabled business that is less than 10 years old." – Startup Genome
- "a young business venture … with innovation at the core of their product or service offering, and plans to rapidly scale." – UK Tech Nation
- "a company who has an average annualised return of at least 20% in the past 3 years, with at least 10 employees in the beginning of the period" – OECD

Although on the surface these seem reasonable, issues quickly arise in application. For example, how can we tell which businesses have innovative business models? Which businesses are technology enabled? Which plan to scale quickly?

It is recognised that different definitions are useful in a variety of contexts - program criteria, policy, research and macro-economic analysis - these can have limited usage when attempting to compare across jurisdictions/locations.

We therefore consider more objective alternatives to provide:

1. an upper limit to the numbers of businesses in "startup" and "young firm" stage
2. a more exclusive estimate of "startups" and "young firms" which may better align with the traditional "technology" focus.

Fundamental Definitions

The *Organisation for Economic Development* distinguishes businesses by age, and not maturity and/or size.[88]

We can extend this methodology for Young Firms and Startups by further excluding "Government" or "Superannuation" business entities:

Table 15: Fundamental young firm and startup definitions

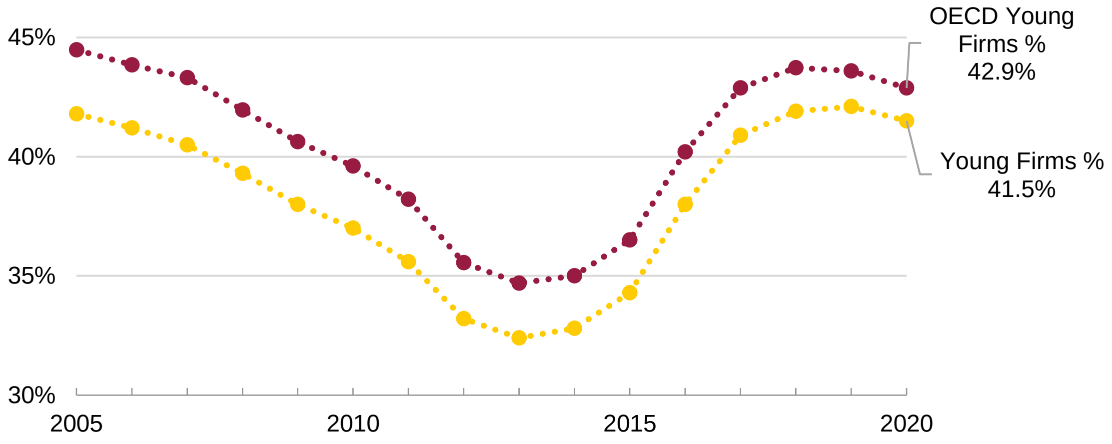
Category	Base OECD condition	Extended condition
Young Firm	*0-5 years old*	*Entity Type is not "Government" or "Superannuation"*
Startup	*0-2 years old*	

Note here that *<u>Startups are a sub-set of Young Firms</u>*.

[88] Criscuolo, C., P. Gal and C. Menon (2014), *The Dynamics of Employment Growth: New Evidence from 18 Countries*, OECD Science, Technology and Industry Policy Papers, No. 14, OECD Publishing, Paris, https://doi.org/10.1787/5jz417hj6hg6-en.

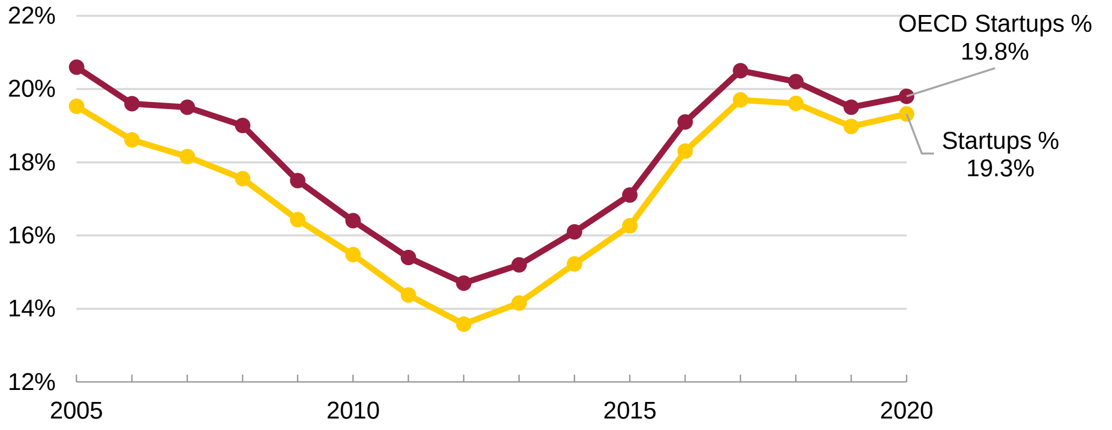
A comparison of these shows the following national results:

Figure 34: Young firms as a Proportion of All Businesses, 2005- 2020



Source: Longitudinal Australian Business Integrated Intelligence (LABii) DataVault - QUT

Figure 35: Startups as a Proportion of All Businesses, 2005- 2020



Source: Longitudinal Australian Business Integrated Intelligence (LABii) DataVault - QUT

We observe the following unsurprising results:

- the extended conditions around entity types are slightly more exclusive than the base OECD condition
- there are less startups than young firms

As such, ongoing definitions of startups and young firms will continue as a combination of both the OECD and extended conditions, and will serve as the 'upper limit' for methodologies which are more exclusive (future variations, for example, may consider entrepreneurship markers such as Intellectual Property).

Knowledge-intensive Industries

Noting that the prior definition is extremely inclusive and does not consider tech or innovation-oriented factors in its counts, we create a more exclusive measure based on *Trade and Investment Queensland's* (*TIQ*) definition of "*knowledge-intensive*" industries.

That is, industries which depend on a well-educated and skilled workforce for production of goods and services. This is implemented via the *Australian and New Zealand Standard Industrial Classification* (ANZSIC) code which is associated with each business in the *Australian Business Registry*:

Table 16: Criteria for Knowledge-Intensive young firms and startups

Category	Foundational Definition	Extended condition	Tertiary condition
Young Firm	*0-5 years old*	*Entity Type is not "Government" or "Superannuation"*	*Business is in a "knowledge-intensive" industry*
Startup	*0-2 years old*		

In real terms, we see a much more exclusive count across the nation:

Table 17: Estimate of young firms in Australia using different methodologies

	2016	2017	2018	2019	2020
Young firms	*2,905,710*	*3,135,603*	*3,359,824*	*3,655,564*	*3,694,193*
Young firms (knowledge-intensive)	*120,467*	*126,538*	*128,007*	*129,936*	*122,647*
Knowledge-intensive Proportion	**4.1 %**	**4.0 %**	**3.8 %**	**3.6 %**	**3.3 %**

Table 18: Estimate of startups in Australia using different methodologies

	2016	2017	2018	2019	2020
Startups	*1,398,027*	*1,510,880*	*1,570,543*	*1,647,939*	*1,718,619*
Startups (Knowledge-intensive)	*55,681*	*54,609*	*52,657*	*53,122*	*54,084*
Knowledge-intensive Proportion	**4.0 %**	**3.6 %**	**3.4 %**	**3.2 %**	**3.1 %**

Acknowledging that:

- this "*knowledge-intensive*" criterion will undoubtedly be some amount from the 'real' number of tech/innovative young firms and startups
- alternate methodologies may be developed in future,

the measure provides a suitable estimate and baseline of young firms and startups which is over 95% more exclusive than the foundational definition based on just age and entity type.

Appendix C: Stakeholder feedback on the draft SOI Report 2021

Purpose of stakeholder consultation:

1. Get global and technical feedback on the contents of Paper
2. Gauge interest in the State of Innovation (SOI) and future work
3. Gauge demand for QLD innovation metrics and data

Timeframe:

- Completed Draft Working Paper by 30 June
- Consultation period 12-27 Aug 2021
- Feedback via on-line survey, emails and virtual meetings

Feedback and response rate

- Feedback was sought from 41 contacts within 14 organisations
- Feedback was received from the following agencies:
  - Massachusetts Institute of Technology
  - Department of Environment and Science (QLD)
  - Office Qld Chief Scientist
  - University of Qld
  - Qld University of Technology
  - Department of Tourism, Innovation and Sport (QLD)
  - Department of Premier and Cabinet (QLD)
  - Queensland Treasury (OPRTR and QGSO)

Results and Stakeholder Feedback:

- 91% of respondents feel that the findings from the Working Paper are directly relevant to their organisation and work.