



Health of Queensland Science & Innovation **2016**

Science driven knowledge and our performance landscape

October 2016

Office of the Queensland Chief Scientist with the
Department of Science, Information Technology and Innovation



**Queensland
Government**

Preface

The Health of Queensland Science and Innovation 2016 (HOQSI 2016) is the third report in a series compiled by the Office of the Queensland Chief Scientist. Assistance, data and thought provoking discussion were also provided by teams within the Department of Science, Information Technology and Innovation. Our Queensland universities were also consulted on this report and we owe them great thanks for their time and contributions.

HOQSI 2016 is an assessment of Queensland's science strengths and innovation opportunities. The data in this report is viewed through state, national and international lenses and looks at knowledge driven by science and our performance landscape. So is there anything to worry about? Well there are concerns, which Queensland is well placed to handle but we need to act now. This begins with supporting our talented teachers, universities and vocational education and training institutes; retaining our brilliant scientists; improving the translation of research into outcomes; investing in new technologies, schools, businesses and universities; establishing connections; and helping our innovative startups to flourish nationally and internationally.

And let's not forget the good. We have much to celebrate - great research and development, exciting and promising collaborations, and innovative companies. In this report we have also taken the opportunity to highlight some of the great research, researchers and businesses in Queensland today.

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Key observations and recommendations

1. The Queensland Government has made significant and sustained investments in research and development (R&D), both within and outside government, which has helped establish strong capability areas across Queensland. Advance Queensland and Accelerating Advance Queensland are building upon this investment with greater focus on research translation and innovation. Business engagement is central to these initiatives.
2. STEM education is crucial for the Queensland economy. Currently we have a shortage of STEM qualified Queenslanders which will increasingly impact the state's productivity and international competitiveness. Not only is this an issue for the state but at the individual level, literacy in STEM areas (including digital) improves employability and quality of life. Queensland's universities need to build world-standard capability in information technology (IT) and engage more closely with industry to build a workforce with the IT capability Queensland will need in the future.
3. Education is a key driver of productivity. Ensuring our students and workforce are well-educated will lift Queensland's productivity. The first step in this is ensuring STEM subjects are pre-requisites for university entrance, beyond basic science and maths. This will help build a pipeline of STEM skills as well as new teacher capability. Concurrently, professional development opportunities and resources should be extended to current teachers.
4. Queensland's innovation agenda will help develop strong new pathways for innovation and translation. Further investment in R&D by business, higher education and government sectors is required to lift Queensland's R&D intensity above the national average. This was first recommended in HOQS 2014.

Queensland's business and higher education R&D spends remain low in comparison to the OECD and Australian average. Not surprisingly, there is a disjunct between business and higher education investment priorities. Encouraging businesses (small to medium businesses in particular) to engage and invest in R&D will increase productivity, improve competitiveness and establish long-term relationships which will feed the innovation pipeline.



Key observations and recommendations



World Science Festival Brisbane 2016

Brisbane is the only city other than New York to host the World Science Festival with the Queensland Museum negotiating a six year deal to deliver the event. The inaugural 2016 Festival attracted 120,000 people to the four day event.

Photo courtesy of Queensland Museum

5. Queensland (like most of the rest of Australia) has a problem - collaboration - and while we are addressing this, others are leaving us behind. Access to collaborative funding programs such as Linkage Infrastructure, Equipment and Facilities (LIEF) is essential to develop and maintain Queensland's critical infrastructure. If we are unable to compete in this space we will lose our competitive edge to the other states. This will have serious ramifications for our international partnerships which are increasingly important for the state given the scale and complexity of future scientific challenges.
6. The concentration of Australian researchers in the university sector adversely affects the application of new research and the identification of applied research priorities. While the level of businesses working with universities has almost doubled since 2011 we need to do more to become an innovative country.

Our researchers need to have first-hand experience working with industry through short-term industry placements and entrepreneurship needs to be encouraged throughout the education system. The 50 per cent 'residency' requirement for all Advance Queensland Fellowships is an important guide here.

7. Recognising that the majority of Australian researchers are in the university sector, policy initiatives to encourage greater investment by business in university and public research organisations will help promote increased collaboration between business and researchers.

Successful concepts that deliver on this agenda include co-location of innovative businesses and research facilities, industry champions leading by example, joint appointments from successful companies, and an environment that encourages the movement of staff between research and industry.

8. Queensland is gaining a reputation for being a 'startup state'. Strengthening startup formation outside South East Queensland will deliver benefits for the regions and grow our regional economy. Australia needs to address the challenges faced by startup firms in becoming established businesses. The Advance Queensland's \$6 million Regional Innovation Hubs initiative is one program intended to assist in this space.

Introduction

“We now know that the source of wealth is something specifically human: knowledge. If we apply knowledge to tasks we already know how to do, we call it ‘productivity’. If we apply knowledge to tasks that are new and different, we call it ‘innovation’. Only knowledge allows us to achieve these two goals.”

Peter F. Drucker (1993), Management Guru

Science is important to Queenslanders

In March 2016 the Queensland Chief Scientist commissioned research to better understand the current awareness, perceptions and attitudes to science amongst Queensland adults. The research also aimed to understand current engagement and participation levels and importantly parental encouragement and support for the next generation studying science or choosing a science-based career.

72% believe science is critical for our economy



47% feel there are not enough science events and activities in their area

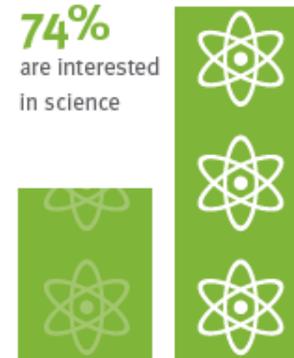


45% feel there is not enough science news and information available in the media or online



only 1 in 5 could spontaneously name a Queensland scientist or scientific discovery

74% are interested in science



Source: Queenslanders' perceptions and attitudes towards science available at <http://www.chiefscientist.qld.gov.au/publications/other-reports>

Science and innovation underpin economic growth



The Queensland Government invests in R&D for a number of reasons. In the past we have invested to create key capabilities, talent and critical infrastructure. In addition, the government also invests in public good research, research that improves the way we live our lives through education, road safety, and disaster response, to name a few.

Our investments in science and research, particularly over the last 15 years, have laid a strong foundation from which we can address future challenges. We have established a global reputation for science excellence and research capability, and achieved some outstanding outcomes.

Queensland needs more than research outcomes alone. Our research is too often 'lost in translation' and the way forward for Queensland will be to develop strong and lasting collaborative partnerships between researchers and industry. These partnerships will be crucial in developing proven technologies and commercial innovation pipelines. It will be through these partnerships that Queensland will deliver job growth, create a vibrant startup community and develop a resilient economy.

Knowledge is a driver of productivity

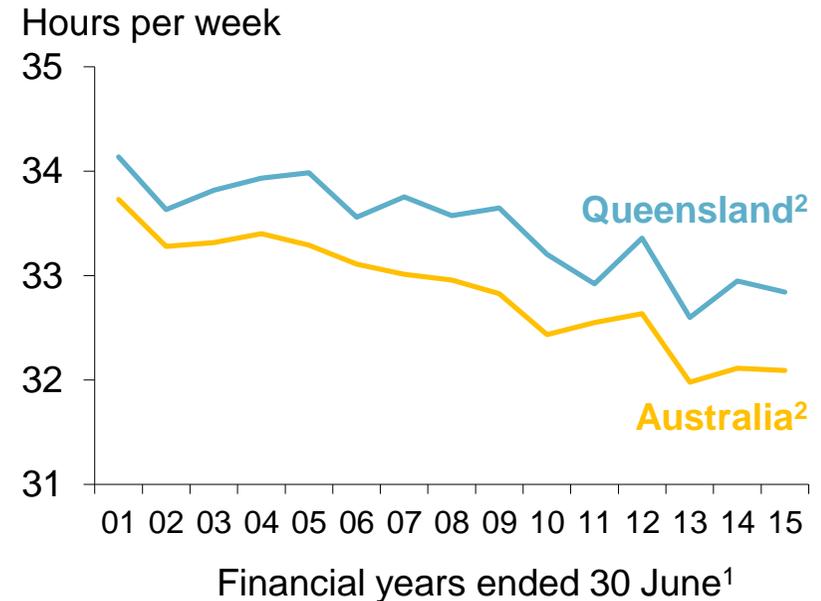
Nothing contributes more than productivity growth to reduction of poverty, to increases in leisure, and to the country's ability to finance education, public health, environment and the arts¹. But Queensland productivity is 8.5 per cent below the national average and in 2014-15 employed Queenslanders worked about 0.8 hours more per week than the national average².

At the Queensland Jobs Growth Summit, Saul Eslake, a notable economist, said "I think improved levels of educational participation and attainment are the single biggest factor that can contribute both to higher levels of employment participation and to higher levels of productivity. And, in turn, higher levels of income"³.

In Queensland (and Australia) the services sectors is responsible for an increasing share of total employment, and is expected to contribute the majority of jobs through to the end of the decade². Health care and social assistance is our largest employer with 300,000 workers². The 65,000 nurses and midwives alone outnumber the total mining workforce².

The share of Queensland's economy that comes from the mining sector is slightly below the national average at 8.1 per cent of gross value added, compared to 9.3 per cent for Australia. Likewise mining accounted for only 2.6 per cent of jobs in Queensland in 2014-15 - well below Western Australia's 7.5 per cent and 4.4 per cent in the Northern Territory³.

The Productivity Commission has estimated that more than 60 per cent of Australia's economic growth from 1994-95 to 2005-06 was due to growth in multifactor productivity and investment in innovation⁴. 'There is a need to educate ourselves and work more productively'.



"Queensland workers are effectively working 'one week longer' than workers in other states, but producing less.."

Saul Eslake, Economist³

Sources: 1. Blinder, Alan and William Baumol, (1993), Economics: Principles and Policy, Harcourt Brace Jovanovich, San Diego cited in Eslake, S and Walsh M, 2011, Australia's Productivity Challenge, Grattan Institute, Melbourne 2. Eslake S. (2016) The changing structure of economic activity and employment in Queensland. Presentation to the Queensland Jobs growth summit. Hosted by the Australia Institute Parliament House, Brisbane – 26th April 2016 3. Change needed to boost Qld's productivity: Business April 2016. Brisbane Times <http://www.brisbanetimes.com.au/queensland/change-needed-to-boost-qlds-productivity-business-20160426-gofmth.html> 4. Barnes P & McClure A (2009) Investments in Intangible Assets and Australia's Productivity Growth, Productivity Commission Staff Working Paper, Canberra. Cited in DIISR (2011) Australian Innovation System Report, Department of Innovation, Industry, Science and Research, Canberra.

Accelerating Advance Queensland

Unlocking the potential of business to innovate

\$22.7 m



Advancing Small Business Queensland Strategy

\$10 m



Platform Technology Program

Harnessing existing strengths and fostering emerging opportunities

\$3.9 m



New Agricultural Economy

\$40 m



Advance Queensland Industry Attraction Fund

\$9 m



Industry Accelerators

\$19.7 m



Queensland Biofutures 10-year Roadmap and Action Plan

Building future generations

\$3.3 m



Schools of the Future

\$7.1 m



Global schools

\$25 m



Clinical Genomics Service

\$35 m



Integrated Healthcare Fund

Growing our regions

\$6 m



Regional Innovation Hubs

\$10 m



Cairns Innovation Centre

\$33.5 m



Advance Queensland: Connecting with Asia Strategy

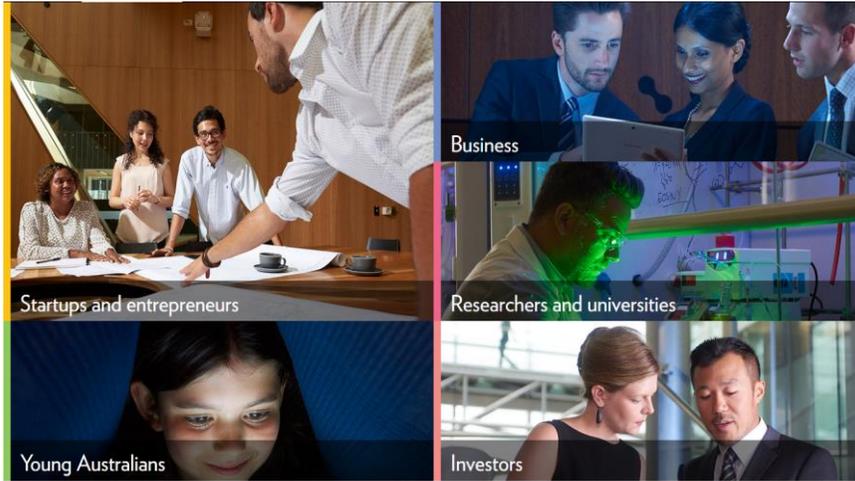
Advance Queensland is part of the Queensland Government's \$1.6 billion Working Queensland jobs plan¹. The \$180 million Advance Queensland initiative is a comprehensive suite of programmes, based on international evidence of 'what works', designed to create the knowledge-based jobs of the future.

Advance Queensland will position Queensland as a place where entrepreneurs, industry, universities and government collaborate to turn great ideas into commercial products and businesses that create jobs.

In 2016, the government announced 'Accelerating Advance Queensland' which will invest a further \$225 million over four years to create the knowledge-based jobs of the future, taking the total Advance Queensland investment to \$405 million²:

- The Advance Queensland initiative includes a series of programs designed to reinvigorate science and innovation to help create the well-paid, knowledge-based jobs of the future which will attract and retain world-class scientific and entrepreneurial talent.
- We are building an environment where collaboration between industry and research bodies successfully translates ideas and research into commercial outcomes, new and growing businesses, and jobs. This will help to make Queensland a destination of choice for businesses looking to partner with industry savvy researchers.
- We are boosting our entrepreneurial culture by improving access to finance, new business opportunities, and management support for startups and small to medium enterprises (SMEs).

NISA - an opportunity for Queensland



NISA provides opportunities for the Queensland Government to collaborate more broadly with the Commonwealth Government. Both programs strive to support entrepreneurs, startups, innovators, businesses, researchers, and universities and will grow our knowledge economy and help create jobs.

Source: National Innovation and Science Agenda (2015) <http://www.innovation.gov.au/>

In December 2015 the Commonwealth Government released the National Innovation and Science Agenda (NISA). The new measures within NISA have been developed to assist in boosting the commercial returns of publicly-funded research which aligns with the focus of Advance Queensland.

Innovation and science are critical for Australia to deliver new sources of growth, maintain high-wage jobs and seize the next wave of economic prosperity. Innovation is about new and existing businesses creating new products, processes and business models. It is also about creating a culture that backs good ideas and learns from taking risks and making mistakes.

Innovation is important to every sector of the economy – from IT to healthcare, education to agriculture, defence to transport. NISA will drive smart ideas that create business growth, local jobs and global success. The Agenda includes initiatives worth \$1.1 billion over four years. The initiatives will focus on culture and capital, collaboration, talent and skills, and government as an exemplar.



Further information on the National Innovation and Science Agenda is available on the Commonwealth Government's website <http://www.innovation.gov.au/>



Education and skills

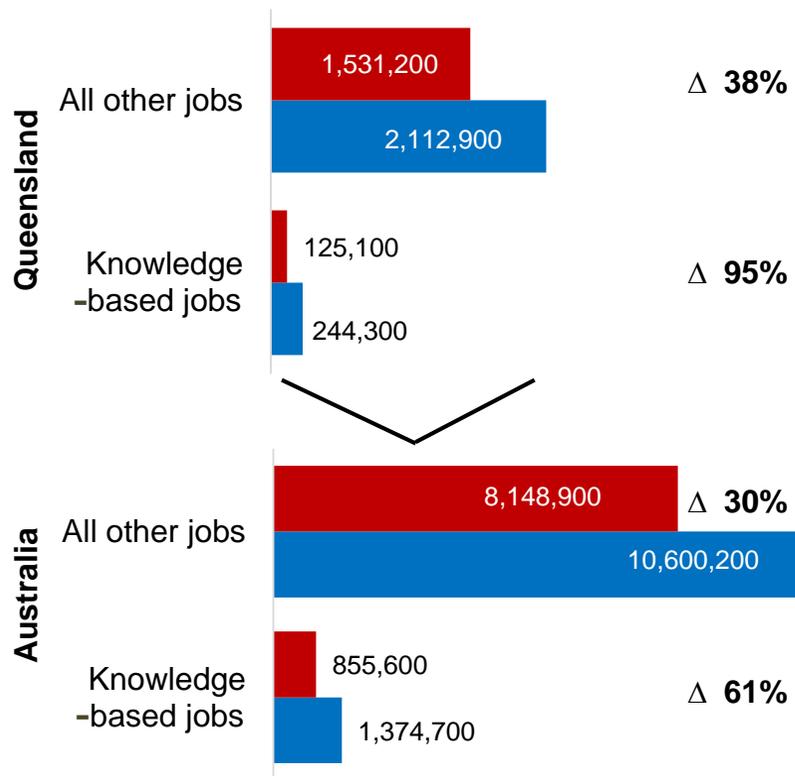
“My best teachers were not the ones who knew all the answers, but those who were deeply excited by questions they couldn't answer.”

Professor Brian Greene, Physicist

Knowledge drives jobs

Employment in Queensland and Australia in 2001 and 2016

■ 2001 ■ 2016



Note: In 2001, Queenslanders made up 14.6 per cent of Australia's knowledge based jobs, in 2015 this rose to 17.8 per cent.

Source: 1. Australian Bureau of Statistics, ABS 6291.0.55.003 Labour Force, Australia, Detailed, Quarterly Labour Force, Australia Catalogue # 6202.0 2. The Royal Society Science Policy Centre, 2014 3. Office of the Queensland Chief Scientist, 2015, Knowledge Intensive Services: growing Queensland's knowledge intensive services sector through science, research and innovation.

In May 2016, over 244,000 Queenslanders worked in knowledge-based occupations* - around 10.4 per cent of the total workforce, up from 7.6 per cent in May 2001¹.

Knowledge-based employment in Queensland grew by 95 per cent between 2001 and 2016 - two and a half times the growth rate of all other jobs at 38 per cent.

STEM capabilities support advances in manufacturing and also underpin the knowledge intensive services (KIS) sector. KIS are very high value services provided by the private sector and commercial public sector organisations that use knowledge and technology to drive their business e.g. accountants, engineers, scientists and architects.

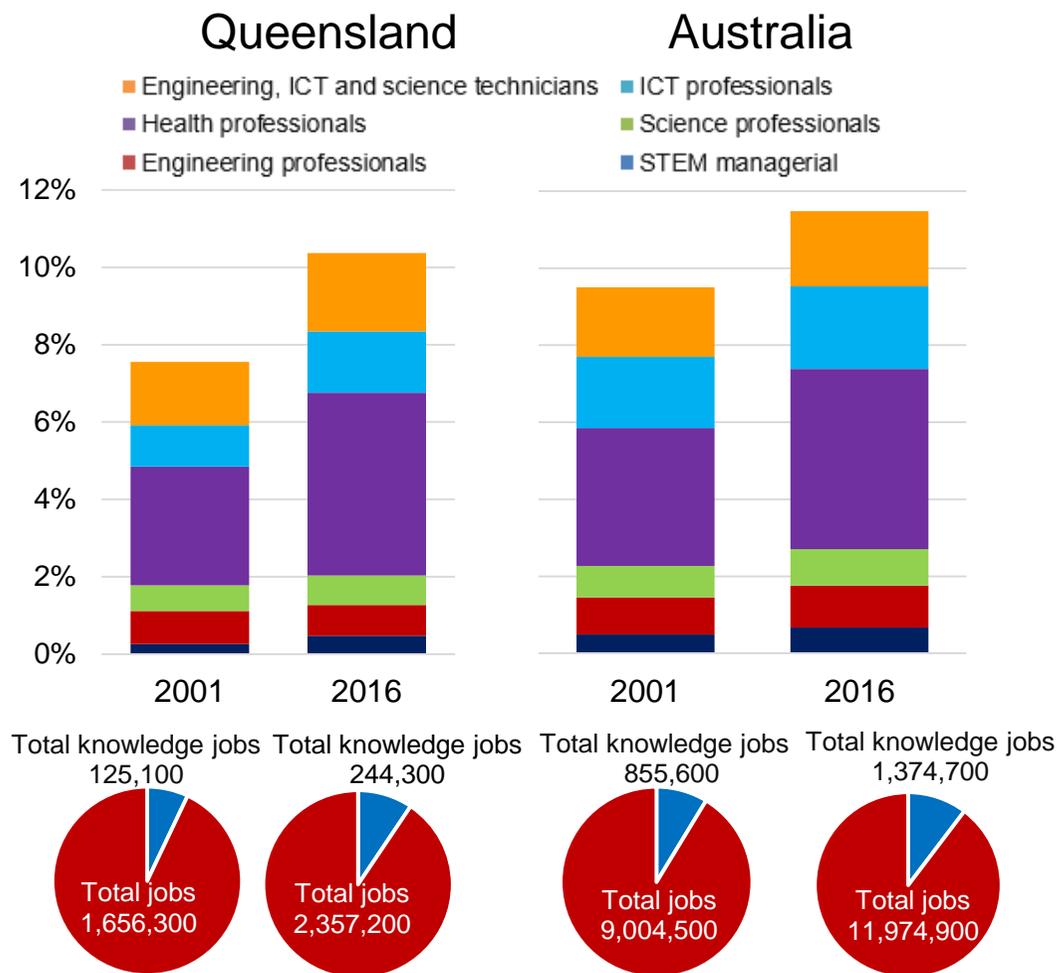
In fact, between 1994 and 2014, full time jobs in the KIS sector grew 77 per cent, compared to only 58 per cent in the traditional services sector and 46 per cent in the total job market³.

“Science and mathematics are at the absolute heart of modern life. They are essential to understanding the world and provide the foundation for the UK's future economic prosperity².”

***Note:**

Knowledge based occupations are those requiring STEM skills/qualifications and include the following ABS occupation categories and codes: engineering professionals (233), natural and physical science professionals (234) [also including actuaries, mathematicians and statisticians (2241)], health professionals (25), ICT professionals (26), STEM managers [encompassing research and development managers (1325), engineering managers (1332), ICT managers (1351)], engineering, ICT and science technicians (31). STEM skills and qualifications are also relevant in other occupations not captured under this definition.

STEM - increasingly a driving force behind job growth



The knowledge workers showing the greatest increase in Queensland between 2001 and 2016 were health professionals, ICT professionals and engineering, ICT and science technicians.

This is similar to the Australian profile where health and ICT professionals experienced the largest increase, followed by STEM managers.

The creation of engineering professional positions has slowed in Queensland in line with the slow-down of the resources sector. However long-term demand for both health and ICT services is expected to increase as the state's population ages, and Queensland and Australia become increasingly engaged with the digital economy.

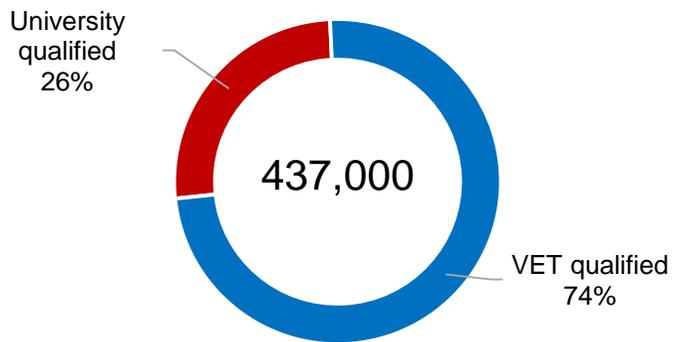
Following very strong increases in health professionals and engineering, ICT and science technicians, Queensland now has above the national average for these STEM jobs.

**Note: The knowledge-based workforce was defined here by the following occupation categories and codes: engineering professionals (233), natural and physical science professionals (234) [also including actuaries, mathematicians and statisticians (2241)], health professionals (25), ICT professionals (26), STEM managers [encompassing research and development managers (1325), engineering managers (1332), ICT managers (1351)], engineering, ICT and science technicians (31). STEM skills and qualifications are also relevant in other occupations not captured under this definition.*

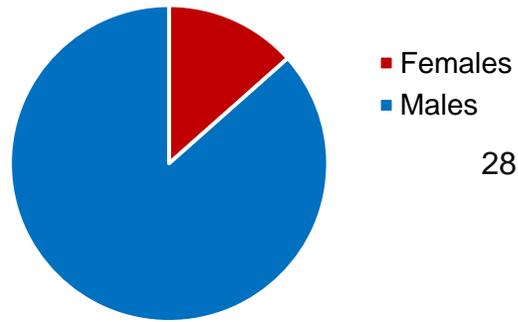
Source: Australian Bureau of Statistics, ABS 6291.0.55.003 Labour Force, Australia, Detailed, Quarterly Labour Force, Australia

Queensland's STEM landscape

**Total STEM qualified* individuals 2011
(20% of Queensland workforce)²**



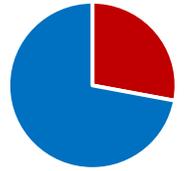
Overall only 13 per cent of all Queensland's STEM qualified people are female



Only 8 per cent with VET STEM qualifications are female



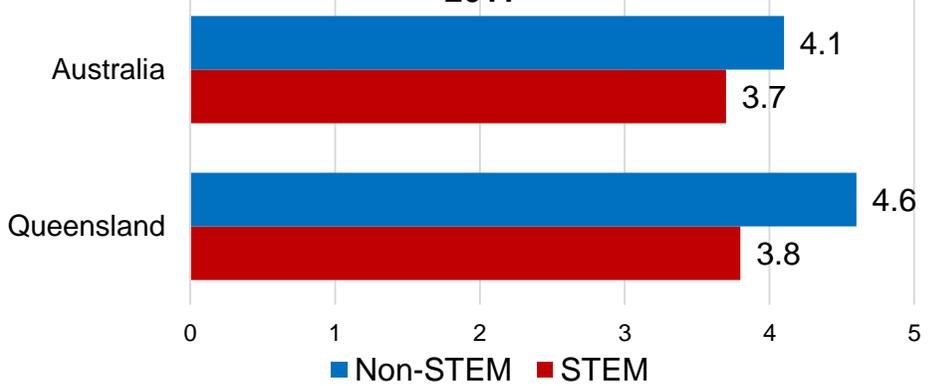
28 per cent with university STEM qualifications are female



*STEM qualified individuals – those who hold a non-school qualification in the natural and physical sciences, information technology, engineering and related technologies and agriculture, environmental and related studies fields of study as defined by the Australian Bureau of Statistics.

Source: 1. Australian Bureau of Statistics, Australian Census of Population and Housing, 2006 and 2011 2. The role of science, research and technology in lifting Australian productivity, 2014, Australian Council of Learned Academies 3. Australia's STEM Workforce, 2016, Australian Chief Scientist

Unemployment rates - STEM and non-STEM 2011



The unemployment rate for STEM qualified individuals was significantly lower than those without a STEM qualification - more so in Queensland than nationally.

In 2011 (latest available data, based on the last census), 20 per cent of Queensland's workforce held a STEM qualification - of which 13 per cent were female. Female participation rose to 28 per cent for those with university qualifications but only 8 per cent for those with vocational education and training (VET) qualifications¹.

A STEM education provides specific job-relevant knowledge but also more general frameworks and approaches to tackle problem solving. Greater levels of STEM qualifications in the general population will help foster an innovation capable workforce critical to increasing productivity. Lifting the number of women with STEM qualifications would not only help improve their employment prospects but would also help increase workforce diversity, a driver of innovation².

Outside work, STEM literacy will increasingly be required to participate more fully in our changing lifestyles and to benefit from technology advances³.

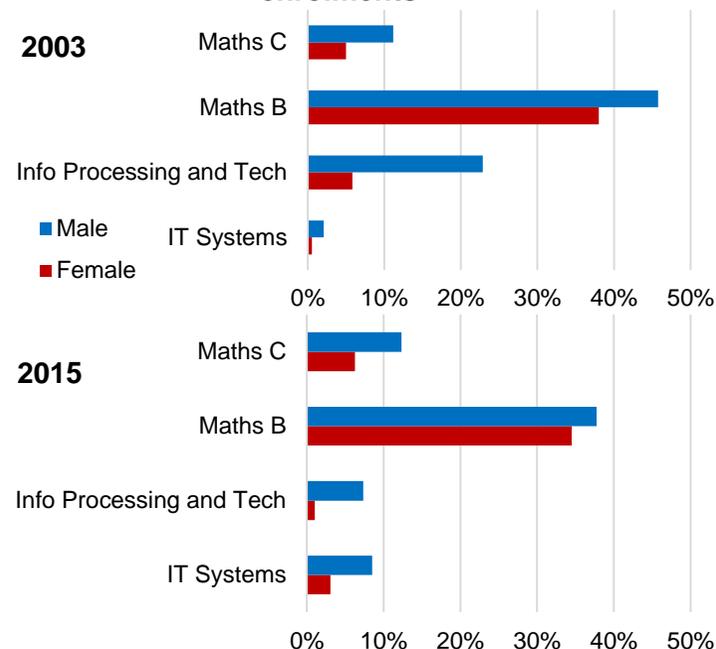
Females need to be encouraged to do STEM

Between 2003 and 2015, the relative proportion of female enrolments increased in IT Systems, Mathematics B and Mathematics C, however with the exception of Mathematics B, did not approach parity. Mathematics B is a prerequisite for bachelor level university courses in engineering, IT and veterinary science, while Mathematics C is often recommended, but not compulsory, for honours degrees in engineering.

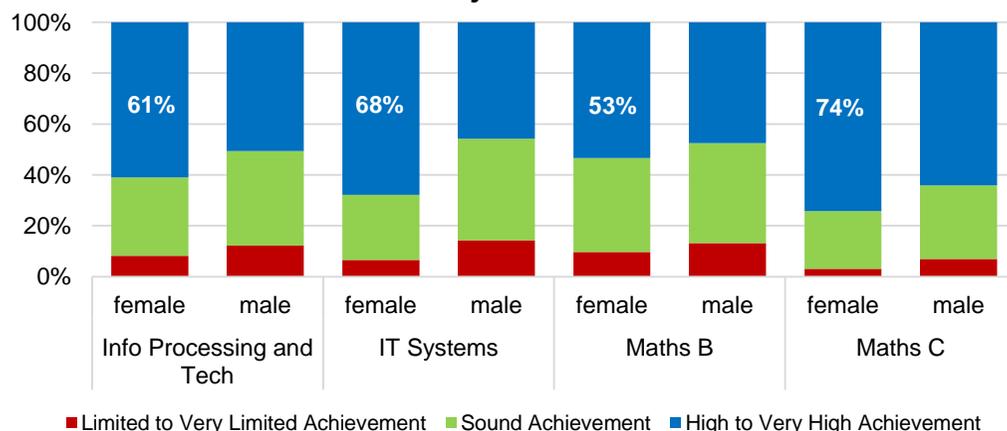
While there have been increases in female enrolments in IT systems and Mathematics C as a percentage of the total Queensland year 12 female cohort, relative female enrolments in advanced mathematics and IT subjects remain significantly lower as girls choose to take up other subjects.

This low enrolment rate contrasts with the achievement of female students in these subjects where without exception, the percentage of girls with a high or very high achievement exceeded that of the boys. In short, fewer girls do mathematics and IT, but those who do, do better than boys. This disjunct between enrolments and ability is a significant concern, particularly as the jobs of the future are likely to require these skill and as highlighted on page 14, STEM based jobs experience the greatest growth.

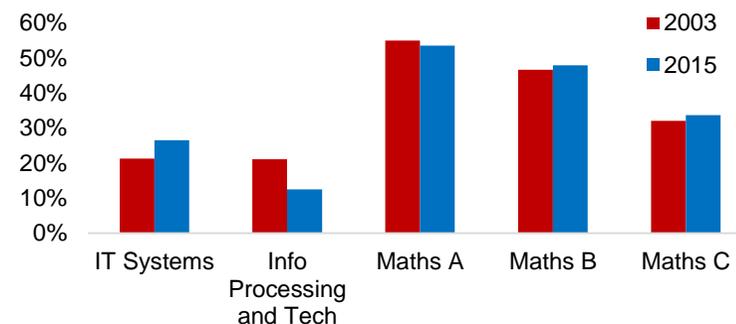
Enrolments in maths and IT subjects as percentage of total male and female student enrolments



Queensland Year 12 Performance in Mathematics and IT subjects in 2015



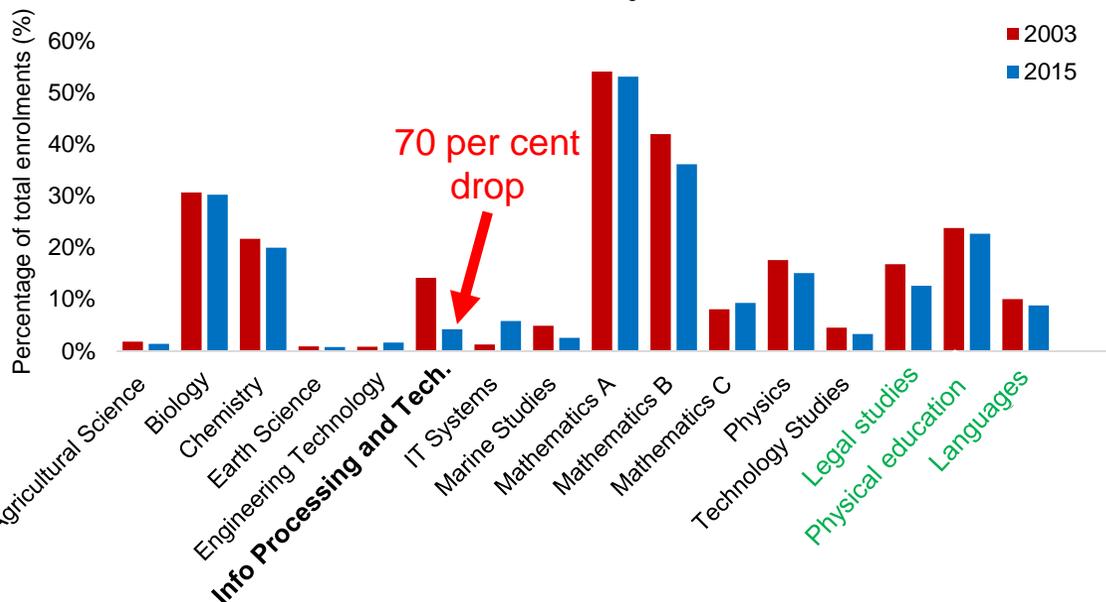
Year 12 female enrolments as percentage of subject enrolments



Source: Queensland Curriculum and Assessment Authority <https://www.qcaa.qld.edu.au/publications/statistics>

STEM participation in high school needs to increase

Year 12 Queensland enrolments for selected STEM and non-STEM subjects²



Enrolments in Year 12 IT courses dropped by 35 per cent in the period. Strong enrolments in the IT Systems subject (only fully rolled out in 2007) were insufficient to offset a 70 per cent drop in enrolments in Information Processing and Technology.

Between 2003 and 2015 year 12 enrolments in Queensland increased from 39,314 to 50,990¹. At the same time enrolments in most STEM Authority subjects dropped by around 23 per cent.

This was more than the drop in enrolments of 5 per cent in physical education and 12 per cent in languages but similar to the decline of almost 25 per cent in enrolments in legal studies. At least part of this drop in enrolments can be attributed to the increased variety of subjects offered over this period¹.

Some STEM subjects went against the trend with enrolments in engineering technology doubling albeit from a very small base, and Mathematics A, the most general mathematics subject, increasing slightly. Enrolments in Year 12 IT courses dropped by 35 per cent in the period. Strong enrolments in the IT Systems subject (only fully rolled out in 2007) were insufficient to offset a 70 per cent drop in enrolments in Information Processing and Technology.

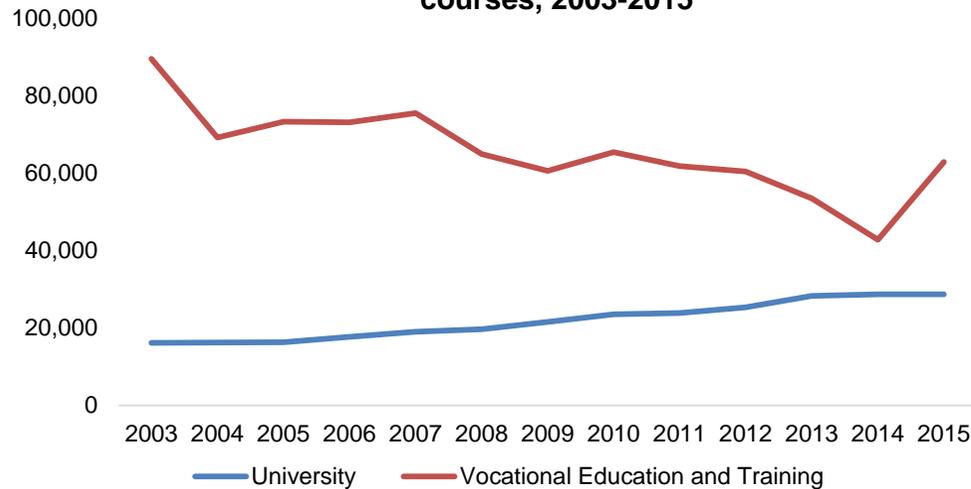
Since 2012 there have been some encouraging improvements with increased enrolments in Biology, Chemistry, Physics and Mathematics B and C, indicating that efforts to improve STEM takeup have been successful, although more is needed to return to earlier levels.

Inspiring students in primary school to see STEM as relevant and interesting is critical for increasing year 12 enrolments. A greater focus on STEM in the earlier grades requires a well resourced teacher cohort, confident in their ability to deliver new subjects like coding and technology and able to embed the concept of lifelong learning in their students². Historically, STEM subjects were prerequisites for many university courses and a return to this as a requirement for relevant courses has been advocated recently by the Australian Chief Scientist³.

Source: 1. Queensland Curriculum and Assessment Authority <https://www.qcaa.qld.edu.au/publications/statistics> 2 Interim Review of STEM, 2015, Department of Education and Training 3. Scientist slams reward for lower expectation, Financial Review, 4 July 2016

Fewer vocational enrolments, more university students

Queensland university and VET enrolments in STEM courses, 2003-2015



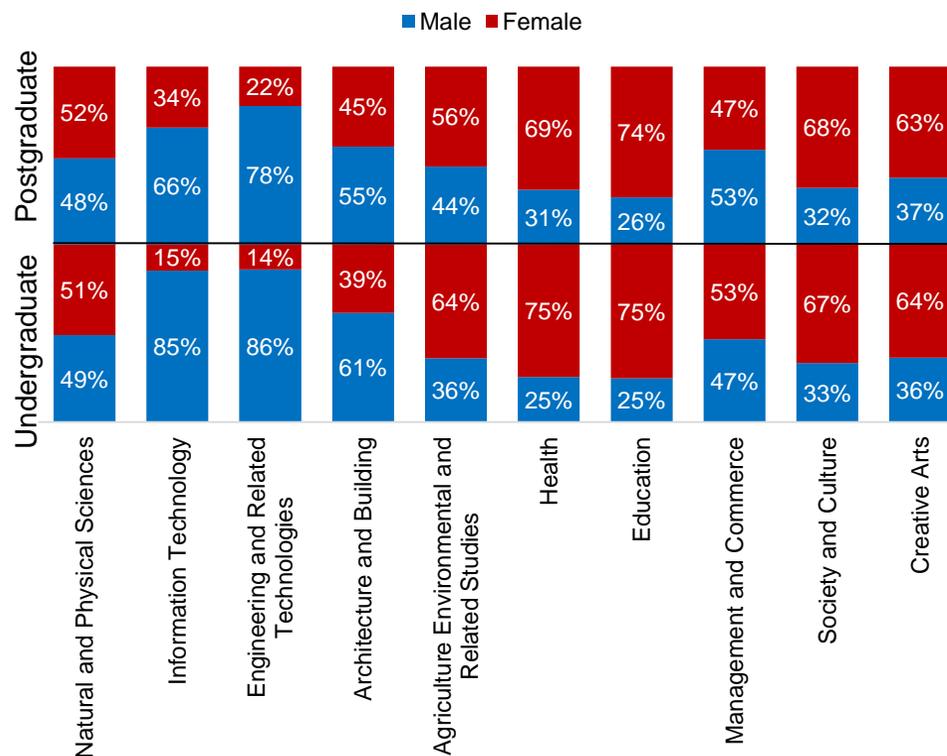
There was a sustained drop in vocational education enrolments both overall and in STEM courses in Queensland between 2003 to 2014, offset by a significant increase in 2015. University STEM enrolments in Queensland are increasing although this trend is not consistent across courses.

In 2015 enrolments in science-related subjects in VET showed a 30 per cent decline from 2003. Surprisingly, university enrolments in STEM have increased by 78 per cent in the same period. This is driven largely by a significant increase in health enrolments.

		2003	2015
Total STEM enrolments	University ¹	16,104	28,624
	VET ²	89,489	62,838
% of total enrolments in STEM	University ¹	33%	40%
	VET ²	30%	22%
Queensland population ³		3.88 m	4.78 m

Source: 1. Australian Government Department of Education – uCube <http://highereducationstatistics.education.gov.au/> 2. National Centre for Vocational Education Research – VOCSTATS 3. Regional Population Growth, Australia and New Zealand, 2003-04 (ABS cat. no. 3218.0), 3218.0 - Regional Population Growth, Australia, 2014-15.

Gender disparity in enrolments continues at university for Queensland



In 2015 women made up 59 per cent of all domestic enrolments at Queensland universities compared to 56 per cent in 2001. There were over 32,600 more females at university in 2015 than males, but this is not evenly distributed across courses.

The traditionally male dominated fields of engineering and IT show a slight drop in male enrolments at the postgraduate level, more so in IT than engineering. Female enrolments remain very low - 15 per cent in IT and 14 per cent in engineering at undergraduate, rising to 34 per cent and 22 per cent at post graduate.

By contrast, women are significantly over-represented in health and education at both undergraduate and postgraduate levels.

In the non-STEM subjects, in management and commerce there is a switch between a slight female dominance at undergraduate to a male dominance in postgraduate. All other non-STEM subjects analysed here are dominated by female enrolments in both levels.

A more equal balance of male and female enrolments across all courses would lead to greater workplace diversity and productivity.

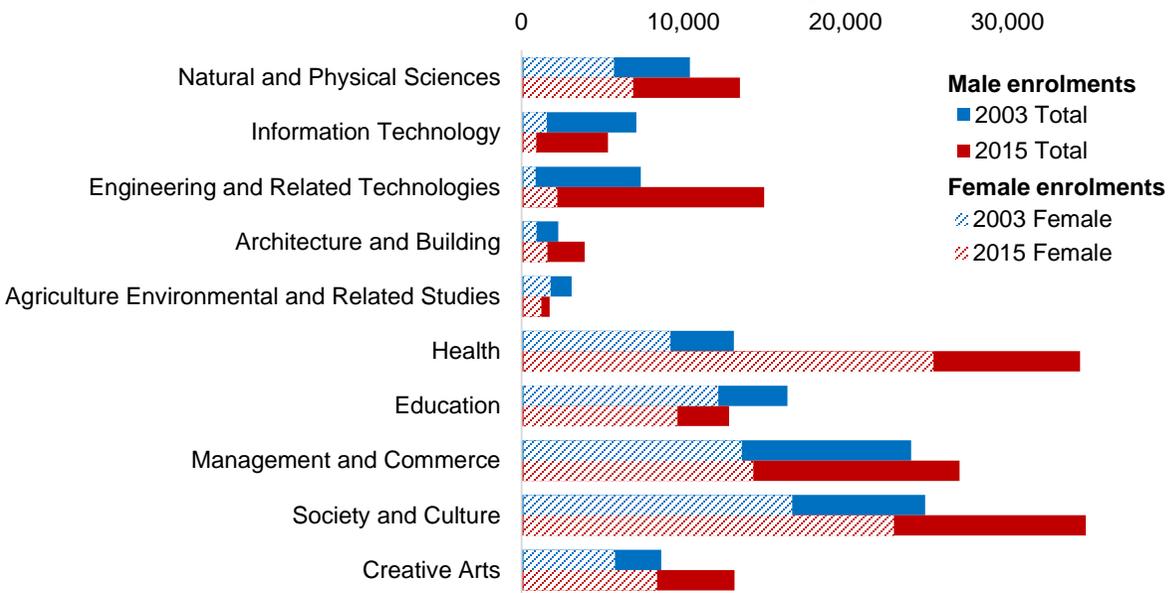
Total Queensland university enrolments in 2015

	Natural and physical sciences	Information technology	Engineering and related technologies	Architecture and building	Agriculture environmental and related studies	Health	Education	Management and commerce	Society and culture	Creative arts	Total students
Undergraduate	13,490	5,345	14,979	3,915	1,750	34,485	12,820	27,035	34,836	13,143	148,632
% of total undergraduate	9%	4%	10%	3%	1%	23%	9%	18%	23%	9%	
Post-graduate	2,293	817	1,615	564	674	8,000	6,388	6,799	6,052	1,207	34,368
% of total post-graduate	7%	2%	5%	2%	2%	23%	19%	20%	18%	4%	

Source: Australian Government Department of Education – uCube <http://highereducationstatistics.education.gov.au/>

STEM participation at university needs to increase

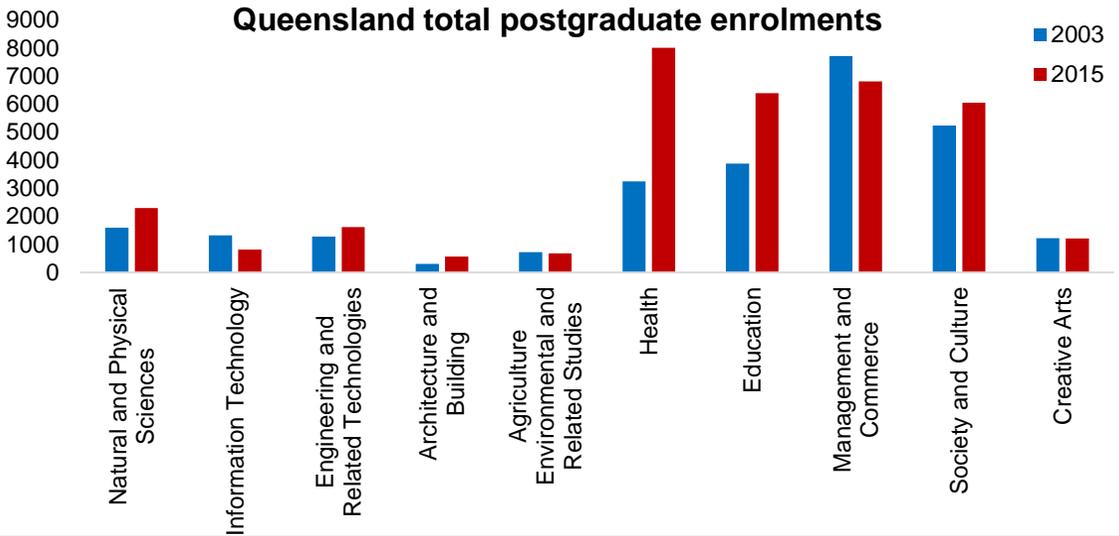
Queensland total undergraduate enrolments



Total enrolments in undergraduate STEM-based courses have generally increased since 2003, although they are overshadowed by enrolments in non-STEM focussed courses such as management and commerce and society and culture¹. IT is a significant exception to this trend, dropping around a third since 2003. However this is where the economy is increasingly focussed and where jobs growth is strong, at both the technical and professional levels.

At postgraduate level, enrolments in health and education exhibit the strongest increases, while the drop in IT enrolments at the undergraduate level is continued at the post-graduate.

Queensland total postgraduate enrolments

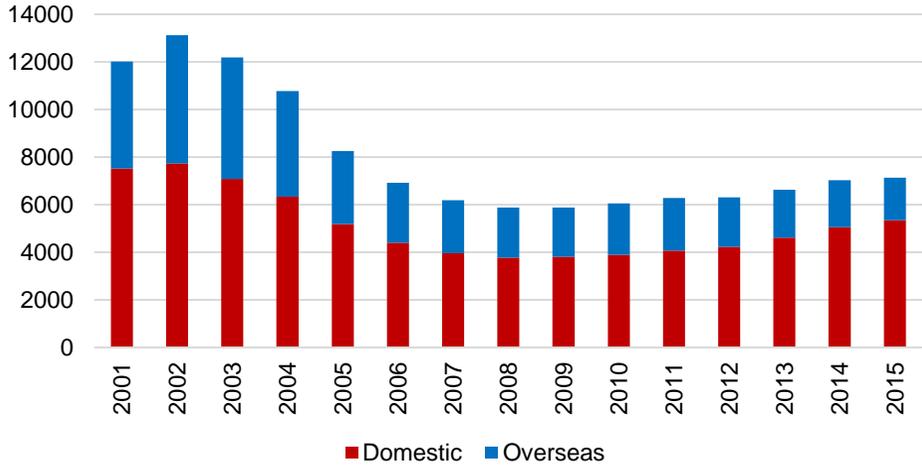


Increased enrolments in STEM subjects at tertiary level will only partially improve Queensland's STEM capability. STEM courses need to be relevant to industry and of high standard. It is of concern therefore that a 2014 survey of Australian university science and engineering deans found that they considered the development of general skill sets more important than having a close fit with the immediate or future needs of employers².

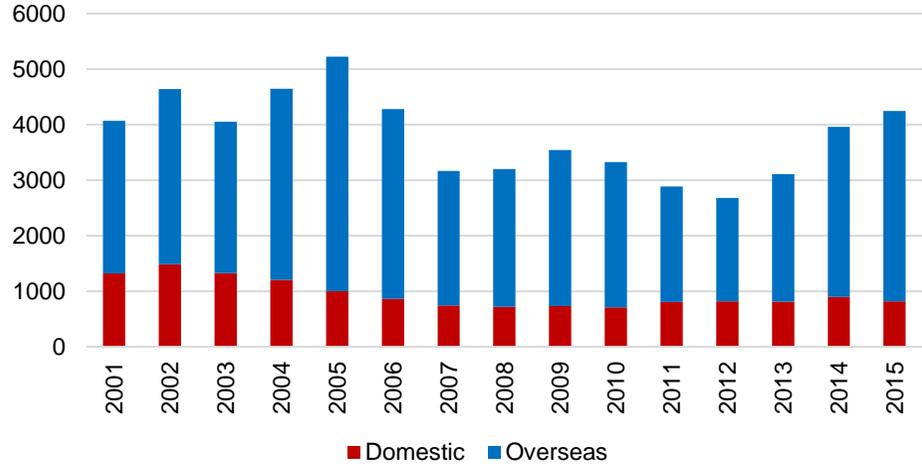
Sources: 1. Australian Government Department of Education – uCube <http://highereducationstatistics.education.gov.au/> 2. Bell, J, Frater, B, Butterfield, L, Cunningham, S, Dodgson, M, Fox, K, Spurling, T and Webster, E, 2014, The role of science, research and technology in lifting Australian productivity, Report for the Australian Council of Learned Academies (p 107)

Queensland not cultivating the IT capability we need

Queensland undergraduate enrolments in IT¹



Queensland postgraduate enrolments in IT¹



The contribution of digital technologies to the Australian economy is expected to grow from \$79 billion in 2014 to \$139 billion in 2020, moving from 5 to 7 per cent of Australia’s GDP². Demand for IT workers is expected to increase but Australia faces a skills shortage in key information and communication technology areas with IT undergraduate enrolments dropping from 2001 and only marginally increasing since 2009.

Undergraduate enrolments in Queensland IT courses dropped more than 50 per cent between 2002 and 2008, increasing slightly in the past six years due to a lift in domestic enrolments. Domestic students have stronger local networks and family ties and may be more likely to either remain in or return to Australia after international experience, building our national IT capability.

At the postgraduate level, overseas students greatly outnumber domestic enrolments over the period, peaking in 2005, but are never less than twice the domestic contingent. Increased domestic postgraduate IT enrolments coupled with strong industry take up of graduates would greatly strengthen the state’s knowledge economy.

The drop in enrolments also needs to be considered within the context of the courses offered. As described on page 45 of this document, Queensland suffers from a significant gap in IT capability having only one institution with above world standard capability³. Highly capable Queensland IT students are likely to be attracted to interstate courses with greater international standings, and may remain interstate at the completion of their studies. This would leave Queensland with an ongoing gap in IT capability.

Source: 1. Australian Government Department of Education – uCube <http://highereducationstatistics.education.gov.au/> 2. Australia’s Digital Pulse – developing the digital workforce to drive growth in the future 3. Excellence in Research for Australia (ERA) Outcomes 2015 National Report, available at <http://www.arc.gov.au/era-outcomes-2015>

Education and skills: Observations and recommendations

- STEM skills are critical for the whole economy, not just for science-related careers. STEM skills are fundamental not only within the science sector, they also make established businesses more competitive and more able to respond to future developments.
- The contribution of STEM skills is highly visible in the emerging knowledge industries like biotech and advanced manufacturing. They are less obvious but equally important in linking established industries like agriculture and mining with innovation and technology.
- It is important that STEM is made an exciting and key part of early education and beyond to ensure future generations have a willingness to learn and develop skills in this area which will be critical for their future. This can include:
 - Supporting teachers with professional development opportunities and resources to build confidence and capability to deliver new subjects like coding and robotics.
 - Expanding the existing school partnerships model to support greater engagement with industry, technology and science partners, and include lower grades to spark interest in these fields at an early age.
 - Making core STEM subjects prerequisites for all university courses to flag the importance of these skills. This would need to be phased in to allow sufficient time to meet the increased demand for STEM teachers and for students to choose subjects based on their intended career.
- While STEM capability is an important and leading export industry for Australia, it is also a critical component to future domestic economic growth. Some STEM subjects have a strong international component and for Queensland institutions to continue to be internationally (and nationally) competitive, ongoing investment in STEM is essential for the delivery of world-class capability both here and to international students.
- With this in mind we need to invest to retain and build domestic capability. Encouraging increased domestic STEM enrolments to ensure that skills developed in the Queensland education system are retained here or are likely to return after gaining international experience.
- Demonstrating the relevance of STEM subjects through practical partnerships with industry and higher education institutions provides hands on experience and lifts retention rates. An expansion of primary and high school partnerships, particularly with industry and technology partners, is needed.
- The declining trend in STEM uptake at secondary school follows through into vocational education. University STEM enrolments are increasing, but are still overshadowed by non-STEM courses like management and commerce. Given the increasing importance of STEM capabilities in tomorrow's economy this is concerning.
- In addition, there is a strong gender imbalance with males dominating in the IT space, particularly at the under-graduate level. This has long-term implications for female employment prospects, workforce diversity and hence innovative capacity.

Education and skills: Observations and recommendations

- According to Excellence in Research for Australia (ERA) (see page 45) few Queensland university IT courses are world standard. Given the increasing importance of digital literacy it is essential that the standard of most if not all of Queensland university IT courses be at least world standard as measured by ERA.
- Applications for Advance Queensland fellowships in the digital/IT priority areas are also low in comparison to the productivity and health focus areas. Early-mid career fellowship applications in the digital/IT priority totalled just over 12 per cent, under half the applications received in the other two sectors.
- Focusing specifically on digital capability, universities need to actively engage with industry to increase the relevance of IT courses and be informed by industry in curriculum development. In addition, industry placement should be a mandatory part of all Queensland IT courses with the default being outside the IT sector, in other industries, to build awareness of the value of IT for the broader economy.
- There is strong gender disparity in enrolments and performance. Female enrolments in advanced mathematics and IT subjects are well below male enrolments, yet a larger percentage of girls receive high or very high achievement when compared to boys.
- At university females dominate in health and education while males dominate in IT and engineering. This not only has implications for future workforce gender diversity but also in the innovative capacity of that workforce. Queensland parents, teachers, government and the community need to encourage all children to study science.
- The jobs being created now and into the future are those reliant on STEM skills. If we don't increase female participation in STEM qualifications we are essentially cutting out a large proportion of the workforce from the jobs of the future.
- Lifelong learning is an integral part of a resilient workforce. As technology advances workers will have to reskill to stay employed. It is important economically for lifelong learning to be integrated in the workplace. This can include employers and universities implementing on-line courses that provide a foundation for new skillsets, e.g. digital literacy, that employees can undertake while working, similar to those developed to support teachers.

Some highlights

Meet Rachael Barnes - her knowledge of numbers has led to a high-flying career¹

Rachael works as an Aircraft Performance Engineer. She calculates and provides take-off and landing data for pilots for day-to-day operations. This means determining the required speeds for take-off based on airport conditions such as temperature, runway length, pressure and mass of aircraft, and the maximum landing weight. She also tests the integrity of new applications that calculate these values and provide technical support for pilots where necessary.

Rachael has a dual Bachelor degree in Science and Engineering. Rachel majored in Mathematics and Mechanical and Aerospace Engineering, gaining invaluable scientific and problem-solving skills.



Sea World and sea creatures - the possibilities with STEM

Marnie Horton graduated from university with a Bachelor of Science majoring in Marine Biology, then worked as a Research Assistant for a Marine Parasitologist at The University of Queensland for two years before touring the world for a year as a backpacker.

Marnie is now responsible for the health and welfare of all the fish, sharks, turtles and rays at Sea World and the turtle rehabilitation program which has been running for more than 30 years. She oversees the staff who look after the animals, as well as the education team and technicians who ensure the water quality in the park is at its best.

During her time at Sea World, Marnie has also been involved in rescuing and rehabilitating wild marine creatures that have become stranded or sick. These animals include whales, dolphins, sharks, rays, birds, turtles, sea snakes, dugongs and seals.



Guinness World Records achievement for Queensland³

On Friday 12 August 2016 a Guinness World Records attempt for the largest practical science lesson was held in Brisbane.

Held at the Brisbane Exhibition and Convention Centre 2900 students and teachers converged to break the Guinness World Records title for the world's largest practical science lesson. During the 30-minute lesson students learnt about magnetism, while smashing the previous record of 2,102 students set earlier this year in South Africa.

The challenge was planned by the Queensland Government as it wanted to celebrate science and technology with the country's young students.



Guinness World Records judge Lucia Sinigagliesi presents an official certificate to the new record holders after the enormous science lesson.

Some highlights

Pregnancy and exercise can mix - CQU contributes to new national guide¹

Sports Medicine Australia's guidelines, compiled with significant input from Central Queensland University (CQU), endorses moderate to vigorous intensity physical activity and exercise during healthy pregnancies.

The guidelines were featured in a recent issue of Sport Health magazine with an article on CQU researcher Mel Hayman's recent research on the exercise behaviours of regionally-based pregnant women.

Ms Hayman's research suggested that for healthy women, physical activity and exercise during pregnancy is not only safe but is associated with numerous benefits for both the mother and unborn child.



CQU researcher Mel Hayman with a copy of the Sports Health magazine that includes the guidelines.

Towards the ultimate question: Are we alone?²

Over the past two decades, we have entered the Exoplanet Era, learning at least that planets are common around other stars. The next 20 years will see a concerted global push to attempt to answer that oldest of questions - and the University of Southern Queensland (USQ) will take a central role.

USQ's exoplanetary Science Group is leading Australia into the Exoplanet Era. At USQ's Mt. Kent Observatory, USQ researchers are building 'MINERVA-Australis', a dedicated Australian exoplanet search and characterisation tool, that will help to revolutionise our understanding of the nature of planets around other stars.

With MINERVA-Australis, USQ will be a vital component of the global push to analyse and explore the vast numbers of exoplanets that will be discovered by NASA's forthcoming TESS mission: the Transiting Exoplanet Survey Satellite. By offering guaranteed follow-up and characterisation for TESS's myriad discoveries, USQ will take a world-leading role in the discovery of planets that might resemble the Earth. In addition, USQ's researchers are leading a global push to better understand stars like our Sun, examining and modelling the Space Weather those stars generate, and in the process greatly expanding our understanding of both other stars, and of the way the Sun would have behaved, in its ancient youth.

Scientists and Mathematicians in Schools³

CSIRO's Scientists and Mathematicians in Schools is a national program that creates and supports ongoing professional partnerships between primary or secondary school teachers and STEM professionals.

Creating and supporting flexible partnerships between STEM professionals and teachers, provides access to real-world, contemporary experiences that promote understanding of the importance of STEM and inspiring students.

There are currently 131 teachers in Queensland registered for the program; however, suitable STEM partners have not been found. Consequently, STEM professionals (including scientists, mathematicians, engineers and ICT professionals) are encouraged to join this program.



Investment and infrastructure

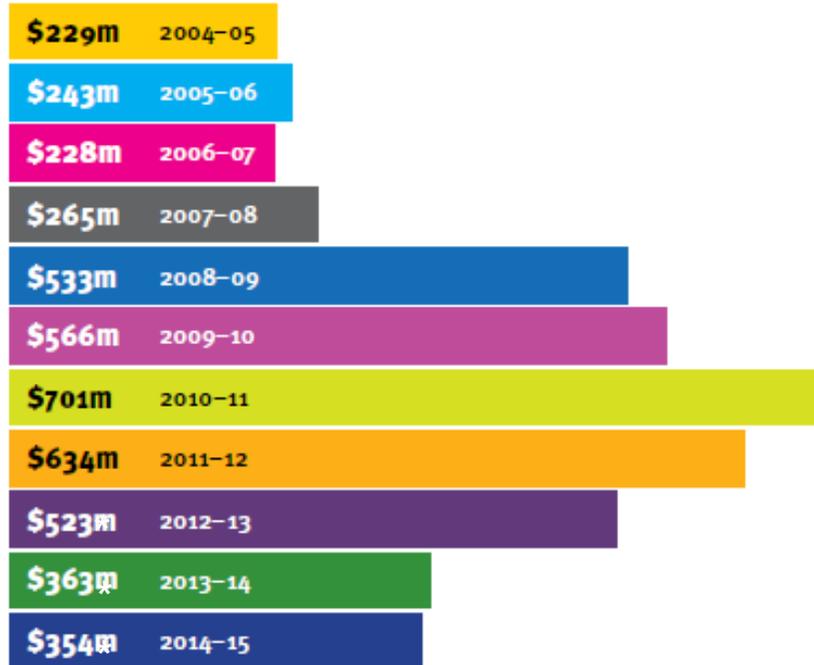
“With our population of 23 million and labour force of 12 million, there’s no other industry that can deliver long term productivity and wealth multipliers like technology. Today Australia's economy is in the stone age. Literally.

...Australia's top 10 companies are a mine, a bank, a bank, a mine, a bank, a bank, a monopoly telephone company, a bank, a supermarket and a superannuation company.”

Matt Barrie, Chief Executive at Freelancer, Knowledge Nation Speech

Queensland Government R&D investment

Total Queensland Government spend on R&D including leverage



**This decrease was expected as major infrastructure commitments have been delivered.*

An additional:
\$0.96

was secured from external sources for every dollar invested by the Queensland Government, from the Australian Government, universities and businesses

In 2014-15:

\$180m

was Queensland Government money

\$174m

was funding that came from external organisations

\$354m

was spent on R&D in 2014-15 —a 3% decrease from last year

Queensland Government spending on R&D

Who spent what in Queensland in 2014-15?

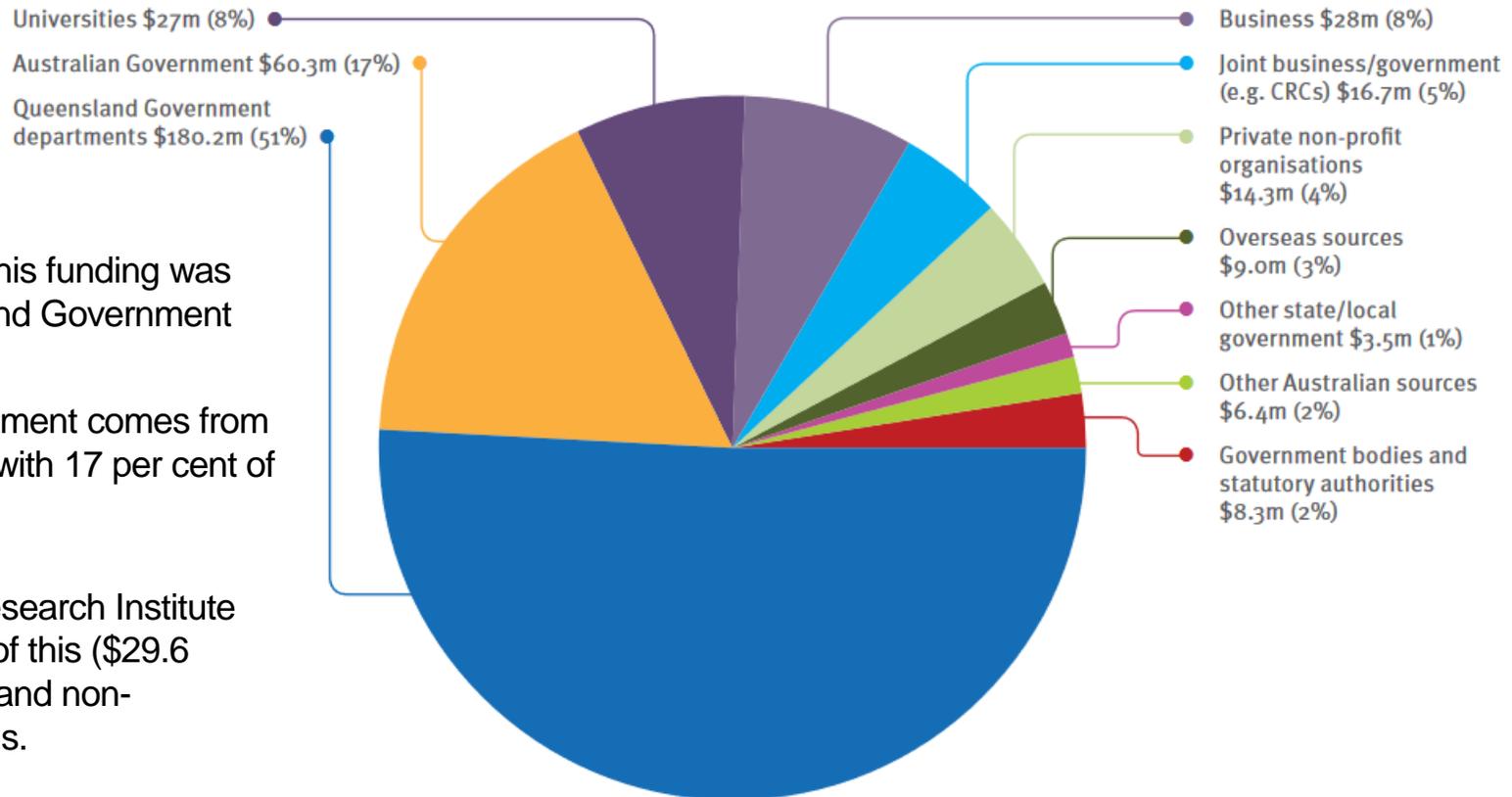
Queensland Government funding supports research performed within government and through external organisations.

In 2014-15, the majority of this funding was sourced from the Queensland Government (51 per cent).

The largest external commitment comes from the Australian Government with 17 per cent of funds (\$60.3 million).

QIMR Berghofer Medical Research Institute received the largest portion of this (\$29.6 million) through competitive and non-competitive funding programs.

This is followed by both the business sector (\$28 million) and universities (\$27 million) each providing 8 per cent of funds.



Source: Queensland Government Research & Development Expenditure Report 2014-15, Office of the Queensland Chief Scientist Office of the Queensland Chief Scientist <http://www.chiefscientist.qld.gov.au/images/documents/chiefscientist/pubs/expend-reports/rd-expenditure-full-2014-15.pdf>

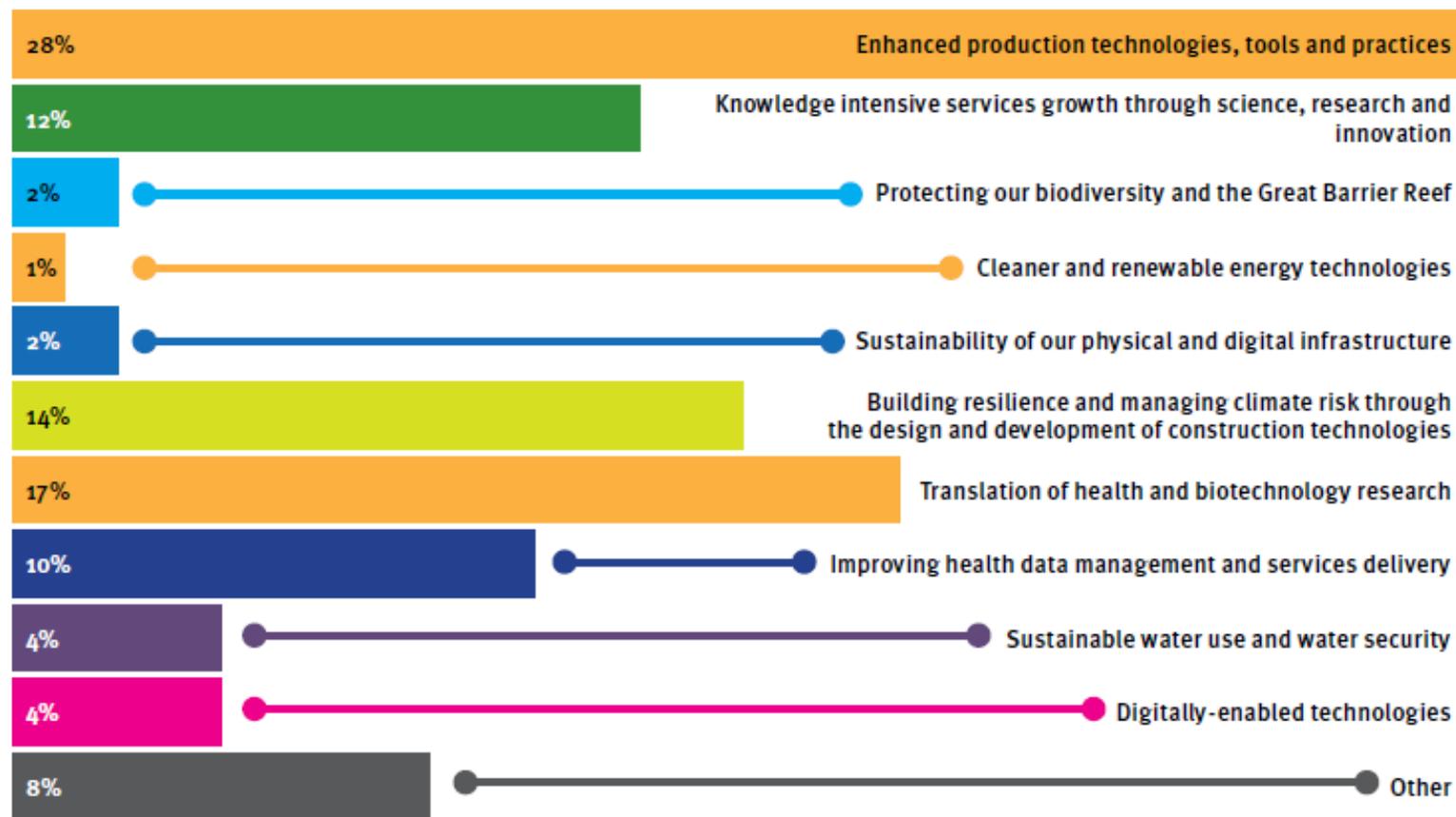
Queensland Government priorities

To ensure future investments provide value for money and align with Queensland Government objectives, the Queensland Chief Scientist has reviewed Queensland's science and research Priorities to ensure they focus on well-defined areas, use our competitive advantages, and reflect identified needs and activities the government considers important. These priorities were developed with industry, academia, and the university and research sector after an extensive consultation process.

In 2014-15, there was significant investment in one Queensland Science and Research Priority area due to historical investment in the agricultural and engineering sectors.

Around 28 per cent of total R&D dollars (\$101 million) was spent on 'Delivering productivity growth and jobs for Queensland by developing enhanced production technologies, tools and practices particularly in the agricultural, mining, advanced manufacturing and supporting sectors including engineering services'.

This was supported by strong investment in the 'Translation of health and biotechnology research...' as well as R&D supporting 'Knowledge intensive services growth...'.



Note: Figures do not add up to 100 per cent due to rounding.

Investment in science, research and innovation

	Smart State (1997-98 to 2011-2012)	Accelerate Queensland (2012 to 2015)	Advance Queensland (AQ) (2015 to 2017)	Accelerating AQ (2016 to 2018) ²
Queensland Government investment	\$2.4 billion	\$7.2 million + \$42 million ² (AITHM*) + \$9 million ² (CJCADR**)	\$180 million (over three years)	\$225 million
Leveraged \$ (inc. leverage from Queensland Government R&D core funding)	\$3.53 billion	\$558.3 million (includes matching funds for AITHM and CJCADR)	\$205.5 million (one year only)	
Queensland Government R&D core funding ¹	\$2.91 billion	\$388 million	\$180 million (one year only)	Released April 2016

Queensland's sustained investment in science, research and innovation has established significant world class infrastructure across Queensland, enabling the state to take advantage of emerging opportunities and challenges of importance to Queensland and the world. In the medical and health area alone there are over 45 new research institutes/facilities showcasing to the world Queensland's excellent research profile. These facilities include: the Queensland Brain Institute, ESKITIS Institute for Drug Discovery, QIMR Berghofer Medical Research Institute, the Translational Research Institute, the Ecosciences Precinct at Boggo Road, and the Australian Institute for Tropical Health and Medicine.

Funding hard infrastructure has been only one part of this investment. Targeted fellowship and scholarship programs have been implemented that support PhD students, early- to mid-career researchers, and world-leading researchers. There are additional opportunities for female and indigenous researchers as well as overseas collaborations and travel with the Queensland-Smithsonian Institution Fellowships.

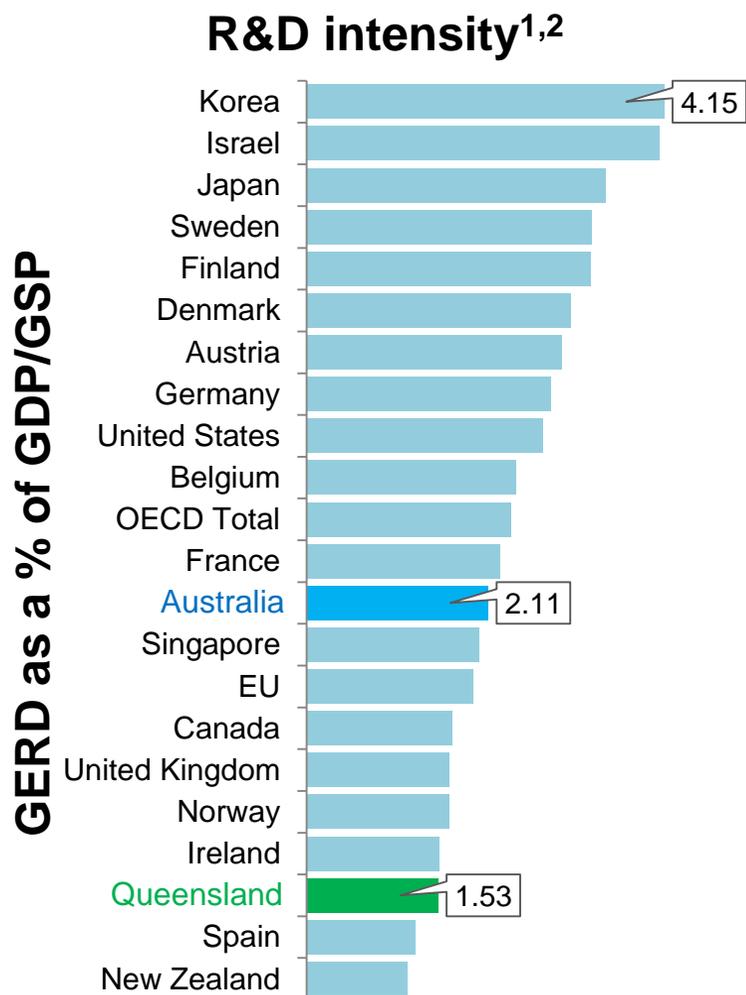
Central to this investment is collaboration. Collaboration between our Queensland universities is important but this is only one aspect. Collaboration between industry and research and between industry partners is a core focus for all Advance Queensland programs and future funding programs. World-class partnerships have been established resulting in world-class research outcomes including the development of a highly innovative High-Field MRI Magnet, clean and low-cost solar electricity, wound healing research, advances in Alzheimer's treatments and many others.

Notes:

1. Queensland Government R&D core funding is funding captured through the Queensland Government R&D Expenditure reports as published by the Office of the Queensland Chief Scientist. This is funding used to support both internal and external R&D activities.

2. The Commonwealth Government provided matching funding of \$42 million to establish the Australian Institute for Tropical Health and Medicine* (AITHM) and \$9 million for the Clem Jones Centre for Ageing Dementia Research** (CJCADR).

Overview of the Queensland R&D landscape



Gross expenditure on R&D (GERD) intensity is the total GERD spend expressed as a proportion of Gross State Product/Gross Domestic Product (GSP/GDP). In 2013, Queensland's GERD intensity was estimated to be 1.5 per cent¹.

While Queensland GERD intensity has grown by more than 50 per cent in the last two decades¹, our investment is still low by national and international standards.

Queensland at 1.53 per cent (compared against countries with a similar population) is well behind world leaders such as Finland (3.3 per cent), Japan (3.47 per cent) and the USA (2.74 per cent)².

Note: The published ABS datasets listed below were used to estimate GERD values for Queensland for 2013-14.

Sources: 1. ABS, Research and Experimental Development, Businesses, Australia, 2013-14 Cat # 81040DO001-201314, ABS, Research and Experimental Development, Higher Education Organisation, Australia, 2014 Cat # 81110DO001_2014, ABS, Research and Experimental Development, Government and Private non-profit organisations, Australia, 2012-13 Cat # 81090DO005_20122013 2. OECD, Main Science and Technology Indicators, www.oecd.org/sti/msti.htm

R&D spending in Queensland is lagging

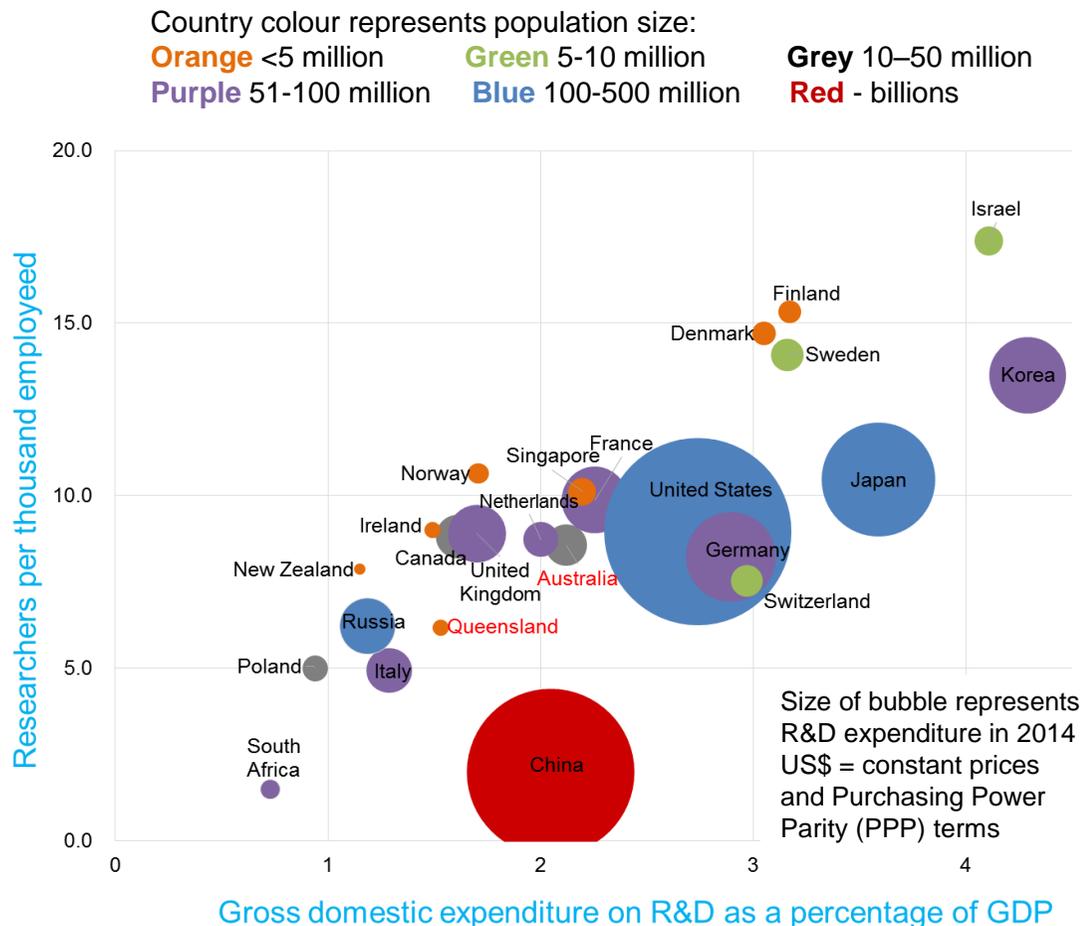
Australia's R&D spend places it among the leading innovative countries in the world.

Queensland's R&D spend is estimated to be \$4.9 billion¹ - just 15.5 per cent of Australia's GERD. This is lower than our share of both the economy and population at nearly 20 per cent and has been for some time. To be competitive we will need to boost R&D investment.

Australia has a similar percentage of researchers in its workforce compared to Canada, the United Kingdom, Germany and Switzerland².

Queensland's researcher numbers are low in comparison to similar populations such as Norway, Iceland, Singapore, Denmark and Finland.

Australia's rate of spending on R&D is now greater than that of a range of other countries, but it is significantly less than that of smaller Scandinavian countries. Spending on R&D in the Australian higher education sector is just over half the rates of Sweden and Denmark.

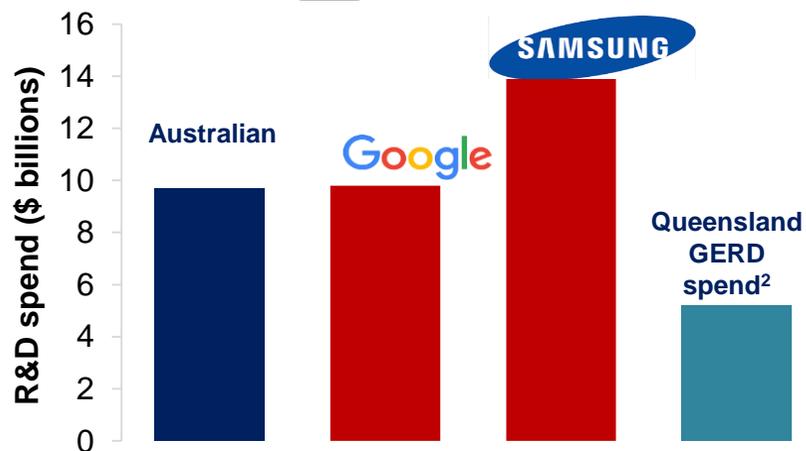
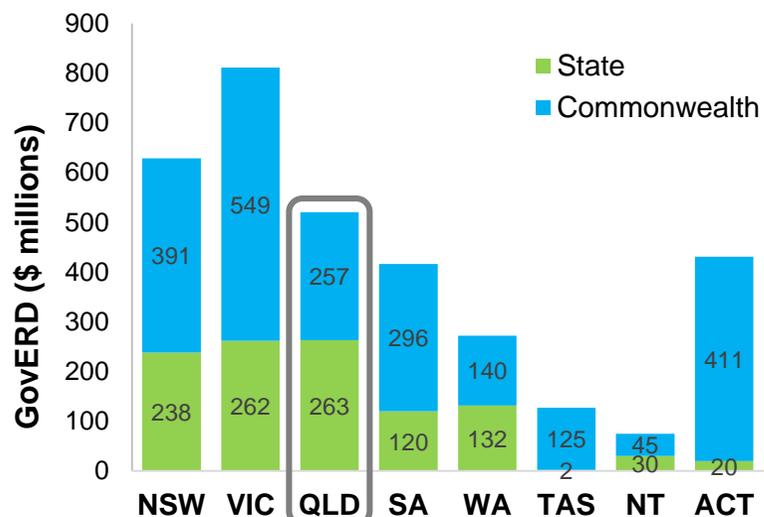


Researchers data is in full-time units and refers to 2013 except for Australia (2008), Brazil and India (2010), Canada and the United States (2012), and Mexico (2011).

Sources: 1. Australian Bureau of Statistics, Cat. No. 8104DO001_201314 Research and Experimental Development, Businesses, Australia, 2013-14 (released 4 September 2015); ABS Cat. No. 8109DO001 and ABS Cat. No. 8109DO005_201213 Research and Experimental Development, Australia, Government and Private Non-Profit Organisations (released 9 July 2014); ABS Cat. No. 81110DO001_2012 Research and Experimental Development, Higher Education Organisations, Australia, 2012 (released 20 May 2014) 2. OECD, Main Science and Technology Indicators database, www.oecd.org/sti/msti.htm

Is Queensland spending enough on R&D?

Commonwealth Government and State Government R&D expenditure for 2014-15¹



The latest state-related data from the ABS¹ shows that in 2014-15 direct Commonwealth and state government expenditure on R&D amounted to \$3.33 billion down 11 per cent from \$3.73 billion* in 2012-13.

Victoria has the largest share of both Commonwealth and state funding, as was also the case in 2012-13, with almost double the amount of Commonwealth funding compared to Queensland. Queensland is in the middle of the pack with \$257 million.

In 2014-15, the ABS recorded total GovERD (Commonwealth and state R&D expenditure) in Queensland as \$520 million, with the state government providing greater than 50 per cent of this funding.

Queensland leverages \$0.96 for every dollar it puts in from the Commonwealth. In comparison Victoria leverages \$2.10 for every dollar. Tasmania leverages \$62.50 from the Commonwealth for every dollar and the ACT obtains \$20.55 for every dollar it contributes to R&D.

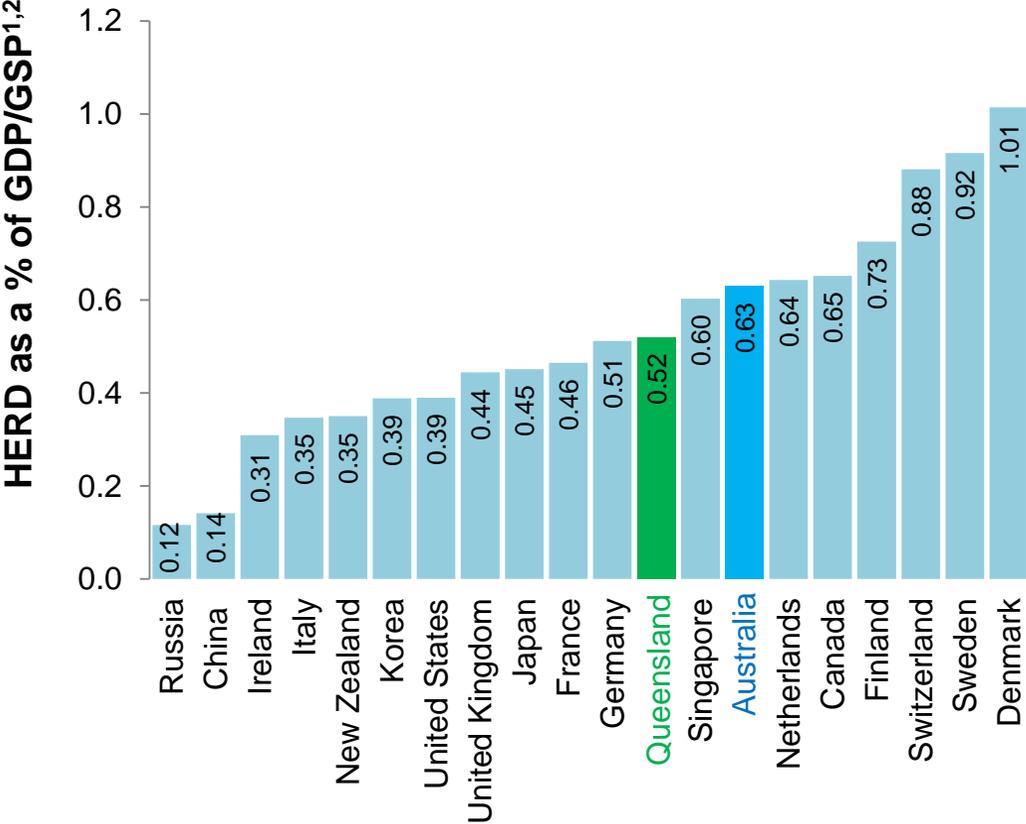
The Australian Government is a major funder of science, research and innovation, providing an estimated \$9.7 billion in 2015-16³.

In comparison, Google spent \$9.8 billion in 2015 and Samsung spent \$14.1 billion in the same year on R&D⁴.

* This expenditure (GovERD) does not include R&D funded by external organisations and it therefore not comparable to the data shown on page 28 and 29.

Sources: 1. ABS Cat. No. 8109DO001 and ABS Cat. No. 81090DO001_201415 Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2014-15 (released 6 July 2016) 2. Australian Bureau of Statistics, Cat. No. 81040DO001_201314 Research and Experimental Development, Businesses, Australia, 2013-14 (released 4 September 2015); ABS Cat. No. 81110DO001_2012 Research and Experimental Development, Higher Education Organisations, Australia, 2012 (released 20 May 2014); Austrade 3. 2015-16 Science, Research and Innovation Budget Tables, <http://www.industry.gov.au/innovation/reportsandstudies/Documents/2015-16ScienceResearchAndInnovationBudgetTables.pdf> 4. <http://www.strategyand.pwc.com/global/home/what-we-think/innovation1000/top-20-rd-spenders-2015>

Investment in higher education research spending



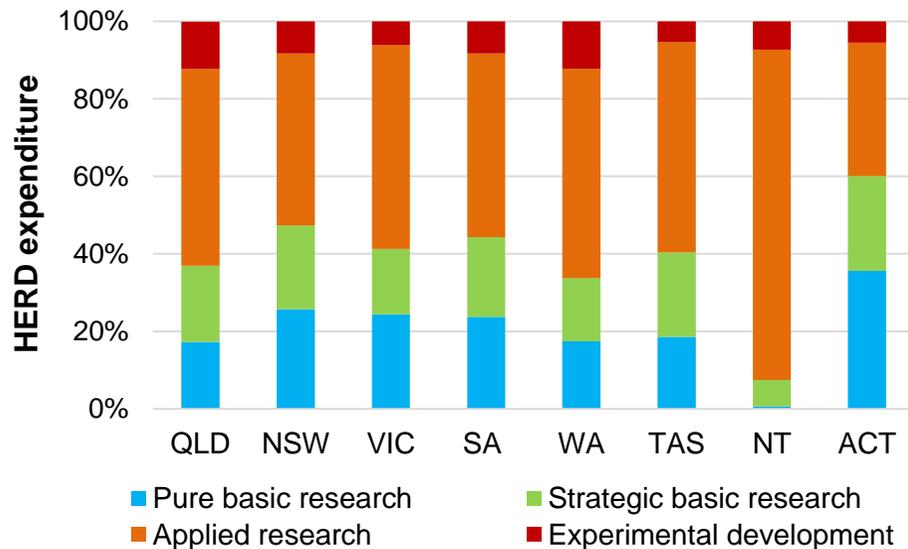
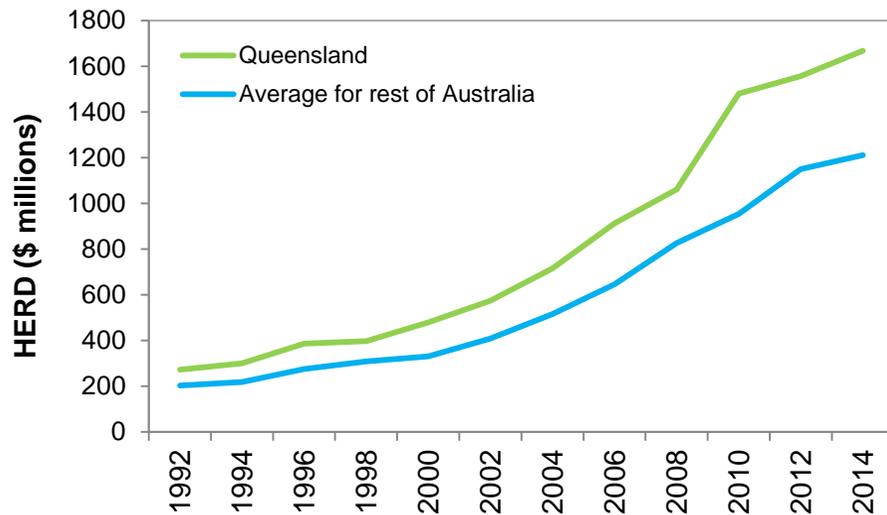
Higher Education expenditure on R&D (HERD) is a strong area of investment for both Queensland and Australia.

Research is a core activity for universities across Australia. Capturing their investment provides an insight into the amount and type of R&D that is performed in the university sector. In 2014, Queensland’s HERD was \$1.67 billion or 0.52 per cent of GSP - well below the Australian national level at 0.63 per cent of GDP¹.

In international terms, Queensland is below the world leaders, and countries like the Netherlands and Canada have surpassed us in investment². Compared to 2012, we have not increased our investment in HERD for Queensland or Australia.

Sources: 1. ABS Research and Experimental Development, Higher Education Organisations Australia, 2014 Cat # 8111.0 2. OECD, Main Science and Technology Indicators (HERD as a percentage of GDP)

Higher education R&D in Queensland



Queensland's higher education research spend is higher than the national average.

On a state by state basis though, Queensland has the third highest spend and has outperformed Western Australia and South Australia. New South Wales has spent almost double the Queensland spend across all four types of higher education R&D.

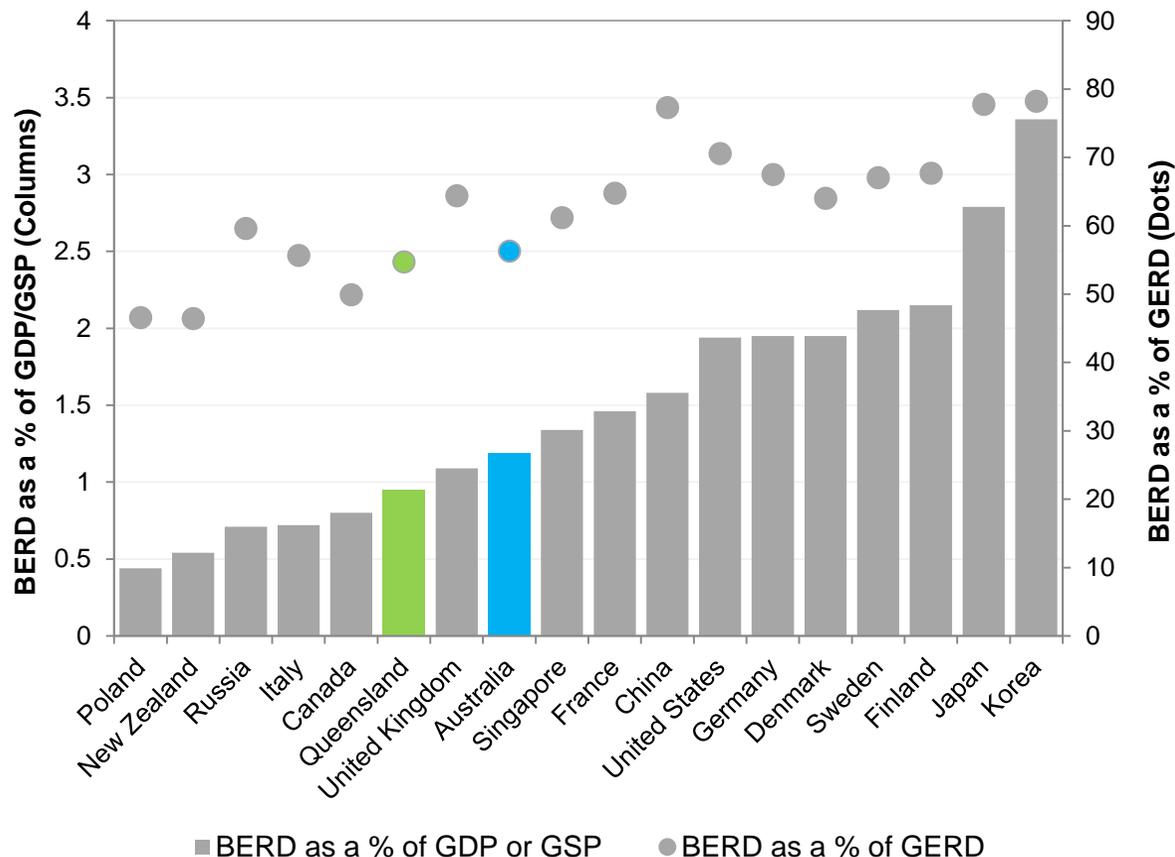
Queensland is tracking well on experimental development R&D in higher education - the type of research that results in the creation of novel materials, products, devices, processes, systems, or services.

Queensland has the highest percentage spend at 12 per cent (as does Western Australia) on experimental development R&D. In terms of actual spend New South Wales has the highest spend (\$261 million) followed by Queensland (\$204 million) in this area.

Source: ABS Research and Experimental Development, Higher Education Organisations Australia, 2014 Cat #8111.0
<http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/8111.0Main+Features12014?OpenDocument>

Business expenditure on R&D

BERD intensity and BERD as a percentage of GERD
(2013-14 or most recent available data)



At approximately 54.7 per cent, Queensland's business share of R&D is similar to global R&D leaders.

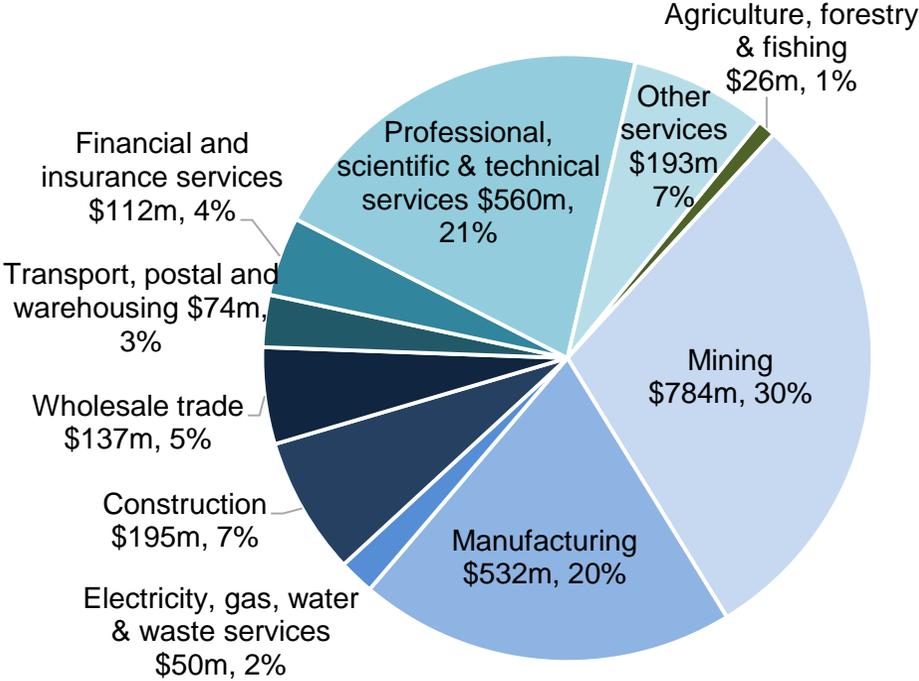
However, Queensland's BERD intensity (BERD as proportion of GSP/GDP) of 0.95 per cent is low compared to the Australian average (1.2 per cent), and is below most OECD nations^{1,2}. Australia's business expenditure is also dropping and has been surpassed by Singapore.

Korean businesses invest proportionally three times more than Queensland, while the United States and Germany spend more than twice as much².

The ratio of research to development in Australian business is estimated to be about 40:60 (compared with 30:70 in the 1990s)³.

Sources: 1. ABS Research and Experimental Development, Businesses, Australia, 2013-14 Cat # 81040, <http://www.abs.gov.au/ausstats/abs@.nsf/PrimaryMainFeatures/8104.0?OpenDocument>
2. OECD, Main Science and Technology Indicators (BERD as proportion of GDP and GERD) 3. Australian Research: Strategies for Turbulent Times (2011), Dr Thomas Barlow

Business expenditure on R&D



In 2013-14 Queensland businesses spent \$2.7 billion on R&D¹.

The bulk of this spend was made by the mining (30 per cent); professional, scientific and technical services (21 per cent); manufacturing (20 per cent) and construction (7 per cent) sectors¹.

The mining and construction industries account for a much greater fraction of Queensland BERD than the national average¹. Although both of these industries have seen a reduction in spend since 2010-11, with mining down 7 per cent and construction down almost 3 per cent².

Note: 'Other' includes administrative and support services; information media and telecommunications; retail trade; rental; hiring and real estate services; health care and social assistance; education and training; and other services.

“Business will be completely transformed by data science. The ability to collect, prepare, manage, analyse, interpret and visualise complex data sets give me competitive advantages in costs and differentiation, and an enhanced ability to collaborate with universities and research institutions (nationally and internationally).”

Professor Mark Dodgson, Director, Technology & Innovation Management Centre, The University of Queensland

Source: 1. ABS, Research and Experimental Development, Businesses, Australia, 2013-14 Cat # 8104.0 <http://www.abs.gov.au/ausstats/abs@.nsf/PrimaryMainFeatures/8104.0?OpenDocument> 2. ABS, Research and Experimental Development, Businesses, Australia, 2010-11 Cat # 8104.0

Investment and infrastructure: Observations and recommendations

- Historically, Queensland has invested substantially in research infrastructure and people and has also developed significant capability in this space. Having established a strong foundation, our focus is now on translating this investment into real outcomes.
- With a strong innovation agenda on the cards for Queensland it will be essential to maintain this core funding and strengthen this investment with federal, university and industry support. This will not only help to overcome budget constraints but will develop strong new pathways for innovation and translation. In comparison nationally and internationally, Queensland still has a low measure of R&D intensity (R&D as a percentage of GSP/GDP).
- As stated in HOQS 2014 we should aim to match or exceed the national average of R&D intensity by 2025. Business, industry and government all have a strong role to play to see this come to fruition.
- Our strengths lie in our science and research priorities. The top five areas provide a diversified and rich portfolio of research alone in areas such as translating health research, and building resilience and managing climate risk area. Queensland also has a developing area of research in the knowledge intensive service industries.
- Queensland's higher education research has maintained a relatively low emphasis on pure basic research and continues to have a greater emphasis on applied research. This is consistent with the government's emphasis on 'practical and applied scientific and technology capability'. However HERD as a percentage of GSP is well below the national average and countries such as Denmark and Canada are surpassing Queensland and Australia in investment.
- Queensland's BERD intensity (BERD as a percentage of GSP/GDP) at 0.95 per cent is low compared to the Australian average (1.2 per cent) and is below most OECD nations - this is a problem as we are lower than most countries and have been surpassed by countries such as Singapore.
- Korean businesses invest proportionally three times more than Queensland, while the United States and Germany spend more than twice as much. We must produce initiatives that encourage industry to spend money on research. Assessing the impact of the Advance Queensland initiative in this space will be important.

Some highlights

Clem Jones Centre for Ageing Dementia Research¹



CJCADR director Professor Jürgen Götz and Queensland Premier Annastacia Palaszczuk at UQ's Queensland Brain Institute

In 2012-13, the Queensland Government committed \$9 million over five years to support the Clem Jones Centre for Ageing Dementia Research (CJCADR) at The University of Queensland's Queensland Brain Institute.

In 2015, the Centre announced the successful laboratory trial and provisional patent of a potential new ultrasound-based dementia therapy. The researchers discovered that ultrasound could be used to destroy the neurotoxic amyloid plaques associated with Alzheimer's disease. This research has been successfully trialled using early disease models, with the next step being trials on further disease models, to work towards and eventually developing a device for use in humans.

SMART Arm medical device³



The SMART Arm medical device, developed by researchers at James Cook University, is a breakthrough in rehabilitating arm function for stroke survivors. The device is innovative in that it combines repetitive training with outcome-triggered electro muscular stimulation; this allows patients to rehabilitate arm function more rapidly than conventional therapy. In clinical trials using the SMART Arm device, patients undergoing a four week course of SMART Arm treatment have shown a 50 per cent better improvement compared to a nine week course of conventional therapy.

The SMART Arm device allows patients with severe arm paresis to initiate therapy through the outcome-triggered electro muscular stimulation. The SMART Arm device also allows patients to work independently of a therapist, and to receive a higher dose of therapy than possible through conventional one-on-one therapy with a physiotherapist.

James Cook University has spun the technology into a company, SMART Arm Pty Ltd, to complete the development and regulatory approval for the device. The device is expected to be available in late 2017.

Commercialisation of Griffith's Group A Strep Vaccine²

PhD student Emma Langshaw and Prof Michael Good from the Institute for Glycomics showcasing their GAS vaccine research for the Hon. Cameron Dick, Minister for Health and Minister for Ambulance Services



Institute for Glycomics researchers, Professor Michael Good AO and Dr Mehruz Zaman, invented a new vaccine candidate to prevent Group A Streptococcus infection (GAS), the causative agent of a number of diseases including pharyngitis and rheumatic heart disease. Worldwide, GAS is estimated to cause more than 500,000 deaths each year. It is particularly prevalent in Australia's indigenous communities and is a major health concern and burden to the health system in China.

Olymvax Biopharmaceuticals Inc. (Chengdu, China) and Griffith University recently negotiated a co-development and licence agreement for Griffith's GAS 'needle free' Liposome Vaccine technology. Olymvax will undertake preclinical development of the GAS vaccine candidate in collaboration with Griffith. Joint vaccine development laboratories have been established in Chengdu and the Gold Coast and upon completion of the preclinical development program, Olymvax will complete clinical development in China and subsequently manufacture and commercialise the vaccine product for the Chinese market.

Some highlights

TraNSTIT - efficient logistics infrastructure in Australian agriculture¹

Over 85 million tonnes of agricultural product is moved from farms to domestic and international markets each year in Australia. Agriculture supply chains in Australia are often characterised by transport distances of over 1000 km between production and markets, with transport costs accounting for up to 40 per cent of the market price.

To address the transport challenges faced by Australian agriculture enterprises, CSIRO developed the Transport Network Strategic Investment Tool (TraNSTIT). This state-of-the-art computer-based logistics tool, co-funded by the Office of Northern Australia and the Northern Territory, Queensland and Western Australian governments, identifies operational, infrastructure investment and regulatory changes that can substantially reduce logistics costs for agriculture at both an enterprise and sector level.

It has been directly adopted for the Northern Australia \$100 million Beef Roads programme, by identifying the transport cost savings for each of the 60 beef road submissions and informing the Australian Government on the selection of submissions that maximises total savings to the northern beef industry.

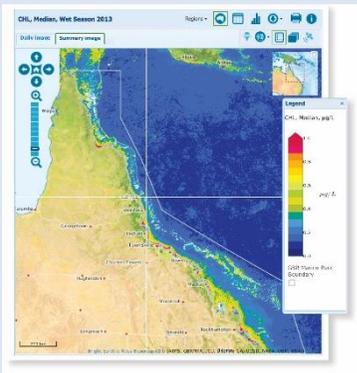
Marine Water Quality Dashboard²

The Marine Water Quality Dashboard uses near real-time data and more than ten years of records of sea surface temperatures, chlorophyll levels, suspended sediments, and dissolved organic matter to provide important information for decision-making.

Dashboard data can be displayed in different formats e.g. maps, tables or charts, and downloaded for further analysis and interpretation.

The Dashboard has been developed through collaboration between the Australian Institute of Marine Science, Bureau of Meteorology, CSIRO, Great Barrier Reef Marine Park Authority and the Queensland Government and is delivered as part of the eReefs project.

Sea surface temperature is an important environmental indicator which can be used to assist decision-making, e.g. helping to predict and respond to coral bleaching events.



Dashboard image showing chlorophyll concentration values for the 2013 wet season.

Cutting hospital waiting times¹



Hospital emergency departments are increasingly overcrowded and can struggle to respond to day-to-day arrivals in a timely manner. Most hospitals would have difficulty meeting the four-hour National Emergency Access Target set by the Australian Government in its 2012 MyHospitals report.

To assist hospitals with this challenging issue CSIRO has developed the Patient Admission Prediction Tool (PAPT), a software tool that uses historical data to predict, with around 90 per cent accuracy, how many patients will arrive at emergency departments and when. PAPT also predicts a patient's medical needs and urgency of care and how many patients will be admitted or discharged.

The system is being used by the Queensland Government and is available in all 27 major hospitals across the state. It has the potential to save \$23 million per annum in improved service efficiency for the Australian health system.

PAPT was developed at the Australian eHealth Research Centre in a partnership between CSIRO, Queensland Health, Griffith University and the Queensland University of Technology.

Performance and collaboration

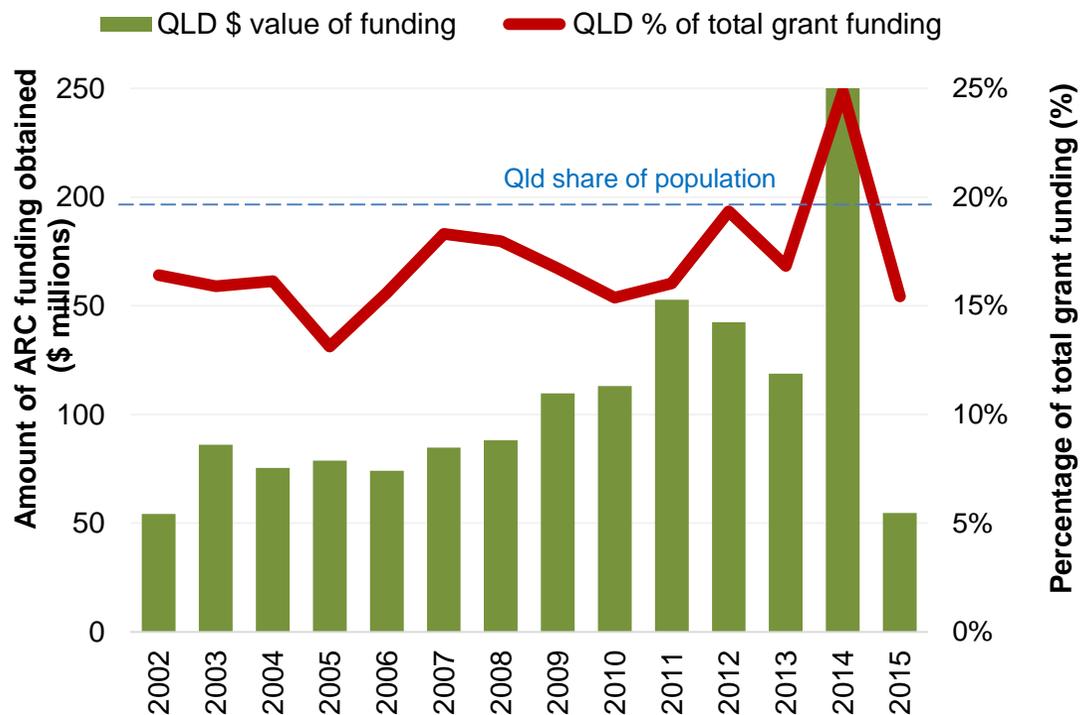
“Hold hands and stick together. There’s a lot of heavy traffic out there.”

Robert Fulghum, Author of ‘All I really need to know I learned in kindergarten’

“In the coming decades, digital engineers (software developers, app developers) will be core in every research team irrespective of discipline.”

Professor Mark Harvey, Deputy Vice Chancellor, Research and Innovation, University of Southern Queensland

Queensland's ARC 2014 funding success is not held in 2015



Note: Some special research initiatives and co-funded centres are not included. Outcomes for 2015 are not complete and do not include funding for Future Fellowships, Australian Laureate Fellowships and Linkage Projects.

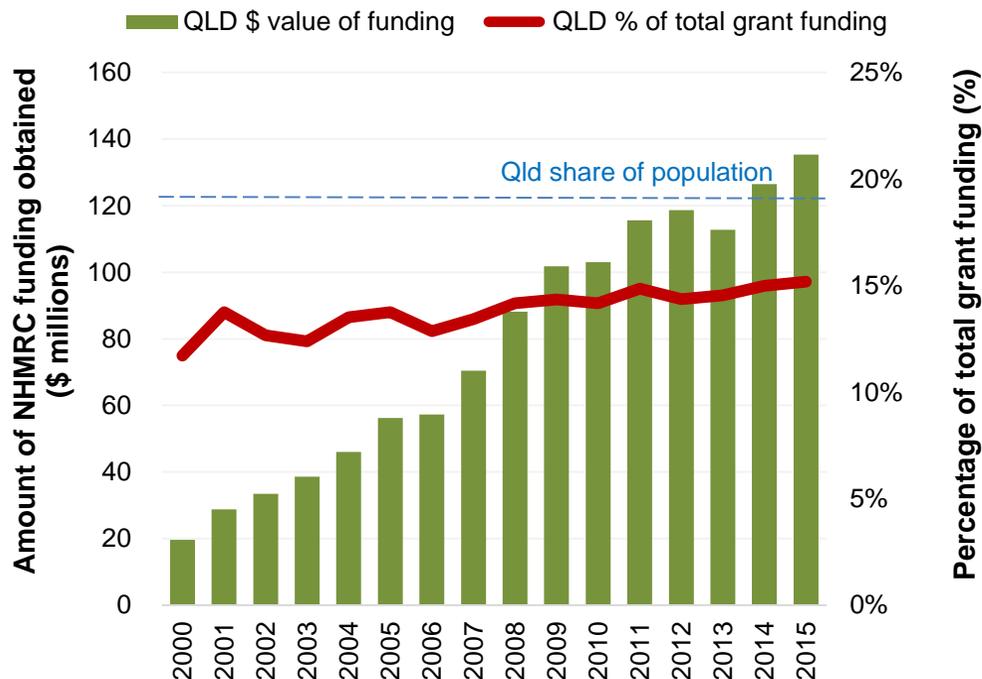
In 2015 Queensland received only 15.4 per cent of total Australian Research Council (ARC) funding down from a high of 24.9 per cent in 2014. However this is the only time Queensland achieved above 20 per cent of total ARC funding.

Queensland consistently ranks third in the rankings of funding allocation with New South Wales and Victoria consistently surpassing us.

And the funding for ARC grants is not increasing. In 2015 the amount of funding released as part of the ARC block grants, decreased by two-thirds, from just over \$1 billion in 2014 to \$354 million in 2015. In fact, the amount of funding available in 2015 was only marginally higher than the \$331 million released in 2002.

Source: ARC <http://www.arc.gov.au/grants-dataset>

Queensland's share of NHMRC funding is stable



Queensland has had a long history of investment in the medical and health sciences. Over time, our ability to attract competitive funding in this area has not increased greatly relative to our state share.

In 2000 Queensland received \$33.4 million in funding from the National Health and Medical Research Council (NHMRC) which increased to \$135.4 million in 2015¹. Our competitive edge has increased with Queensland receiving 15.2 per cent of total NHMRC funding in 2015 up 2.5 per cent from 11.7 per cent in 2000.

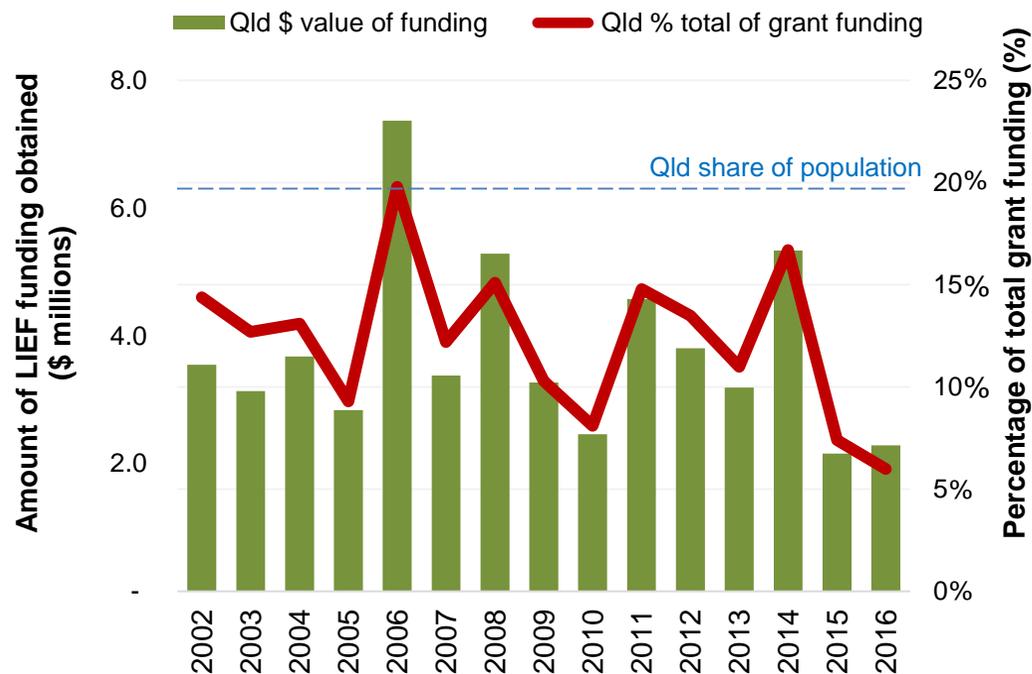
As with ARC funding, Queensland's share of NHMRC funding is below its population share, implying that Queensland is receiving below its 'expected share'. It should be noted that Queensland's share of Australia's GDP is also around 19 per cent³.

"Our survey estimated that 614 working years of scientific time went into the 2014 National Health and Medical Research Council (NHMRC) Project Grant round. That's a massive lost opportunity cost given that success rates were just 15% and will this year fall to a soul destroying 12%.²"

Associate Professor Adrian Barnett, Professor Nicholas Graves and Professor Philip Clarke

Sources: 1. NHMRC <http://www.nhmrc.gov.au/grants-funding/research-funding-statistics-and-data> 2. Let's vote on it: can we use democracy to fund science? <https://theconversation.com/lets-vote-on-it-can-we-use-democracy-to-fund-science-38893> 3. ABS, Australian National Accounts: State Accounts, 2014-15, Cat # 5220.0 (released November 2015)

LIEF funding success rate is low



The ARC-led Linkage Infrastructure, Equipment and Facilities (LIEF) scheme provides funding for research infrastructure, equipment and facilities to eligible organisations to support research. The scheme enables higher education researchers to participate in cooperative initiatives so that expensive infrastructure, equipment and facilities can be shared between higher education organisations and also with industry.

For the latest LIEF round commencing 2016, Queensland received \$2.3 million of ARC funding, only 6 per cent of total funding, positioning us just in front of South Australia.

Queensland submitted 27 proposals, with only three being approved (i.e. 11.1 per cent success rate) by the ARC. This was the lowest success rate of all Australian states.

Source: Australian Research Council (2016) Selection Report: Linkage Infrastructure, Equipment and Facilities 2016, <http://www.arc.gov.au/selection-report-linkage-infrastructure-equipment-and-facilities-2016> accessed June 2016.

Queensland university performance in research

Excellence in Research for Australia (ERA) compares Australian research quality across disciplines and institutions, benchmarked against world standards.

In ERA 2015, Queensland had *well above world standard* in eight of the 11 research fields, spread across five universities.

Griffith University (GU) has shown a substantial improvement with *well above world standard* in three fields and has increased two levels in four fields of research (i.e. physical sciences, chemical sciences, environmental sciences and engineering). The University of Queensland (UQ) has maintained its rankings of *well above world standard* and *above world standard* rankings across all research fields and has increased marginally in earth sciences and environmental sciences. However, we need to be aware that leading interstate universities are demonstrating improvements across a broad range of disciplines.

While Queensland has shown strong improvements in a range of fields there is a concerning gap in the Agricultural and Veterinary Sciences and a weakness in the Information and Computer Sciences area. There is also a gap in the Technology research field which will have flow on effects to Queensland's knowledge economy.

The 2015 rankings again show all Queensland universities have strength in Medical and Health Sciences. However, there is substantial competition in this space from Melbourne University, Sydney University and Australian National University which all obtained or maintained a *well above world standard* ranking.

For Queensland, the most improved research field ranking was in the Environmental Sciences with UQ, GU and James Cook University (JCU) obtaining *well above world standard* in this field, and two universities now obtaining a new ranking of *above world standard*.

2015 vs 2012 ERA		FIELD OF RESEARCH										
		Mathematical sciences	Physical sciences	Chemical sciences	Earth sciences	Environmental sciences	Biological sciences	Agricultural & veterinary sciences	Information & computer sciences	Engineering	Technology	Medical & health sciences
QUEENSLAND UNIVERSITIES	Bond											
	CQU					+2	+1	-1		+1		+1
	GU		+2	+2		+2		-1		+2		+1
	JCU							-1				+1
	QUT			+1						+1	+2	+1
	UQ				+1	+1						
	USQ					ne				+1		+2
	USC					ne	+1			ne		+2
INTERSTATE UNIVERSITIES	Melbourne	+1	+1	+1		+1	+1				-1	
	Sydney		+1					-1	+1	-1		
	ANU			+1	+1							+1
	Adelaide	+1					+1			+1	+1	
	Western Australia					+1	+1	+1	+1			-1

Colour key

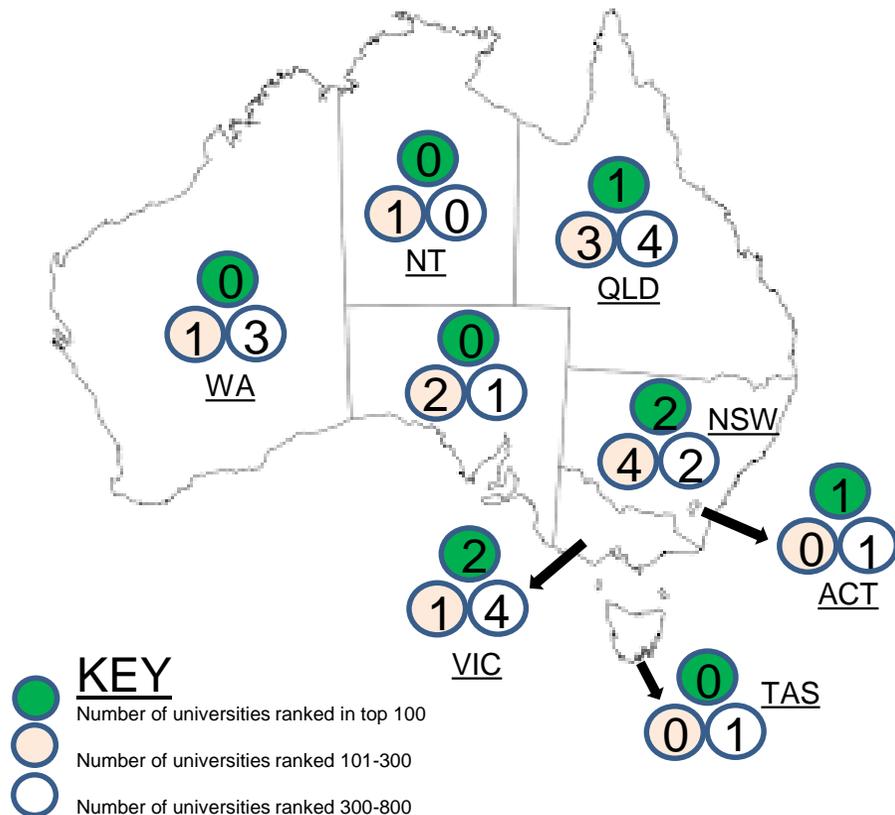
Well above world standard (5)	Below world standard (2)
Above world standard (4)	Well below world standard (1)
At world standard (3)	Not assessed in 2015

Key for comparison to 2012 scores

- +1 Represents an increase of 1 from ERA2012
- 1 Represents decrease of 1 from ERA2012
- ne - new entry for 2015, not assessed in 2012

Source: Excellence in Research for Australia (ERA) Outcomes 2015 National Report, <http://www.arc.gov.au/era-outcomes-2015>

Four Queensland universities in top 300



Times Higher Education World University Rankings is one of several international ranking systems published annually. Others include Academic Ranking of World Universities, QS World University Rankings, and Performance Ranking of Scientific Papers for World Universities.

The *Times Higher Education World University Rankings 2016-17* ranks university performance across a range of core missions, including teaching, research, knowledge transfer and international outlook.

Queensland had one university in the top 100 - The University of Queensland. Three universities ranked 101-300: Griffith University, James Cook University and QUT.

Overall, Queensland could be considered to be ranked third against other Australian states, after New South Wales and Victoria (based on an 'Olympic medal tally' style of ranking).

“Digital disruption and technology cannot substitute the creativity and innovation of humans, so universities will need to educate future scientists on disruptive technologies and critical problem solving and innovation.”

Professor Roland de Marco, Deputy Vice-Chancellor, University of the Sunshine Coast

Source: Times Higher Education World University Rankings 2016-17, www.timeshighereducation.com/world-university-rankings, accessed September 2016.

Queensland's research strengths

Subject area	Ranking amongst Australian states	QLD Field-weighted citation impact (2012-15)
Information Systems and Management	1	2.50
Ceramics and Composites	1	2.32
Applied Microbiology and Biotechnology	1	2.05
Genetics	1	2.01
Cellular and Molecular Neuroscience	1	1.98
Biomaterials	1	1.97
Applied Mathematics	1	1.81
Water Science and Technology	1	1.80
Public Health, Environmental and Occupational Health	1	1.57
Animal Science and Zoology	1	1.49
Psychiatry and Mental Health	4	1.59
Endocrinology	4	1.44
Physiology	4	1.40
Cancer Research	5	1.79
Energy Engineering and Power Technology	5	1.67
Electrical and Electronic Engineering	5	1.59
Food Science	5	1.35
Building and Construction	5	1.28
Plant Science	6	1.72
Mechanical Engineering	6	1.51

Note: Field-weighted citation impact is the ratio of citations received by a publication relative to the expected world average for the subject field, publication type and publication year.

Source: Elsevier SciVal (2016)

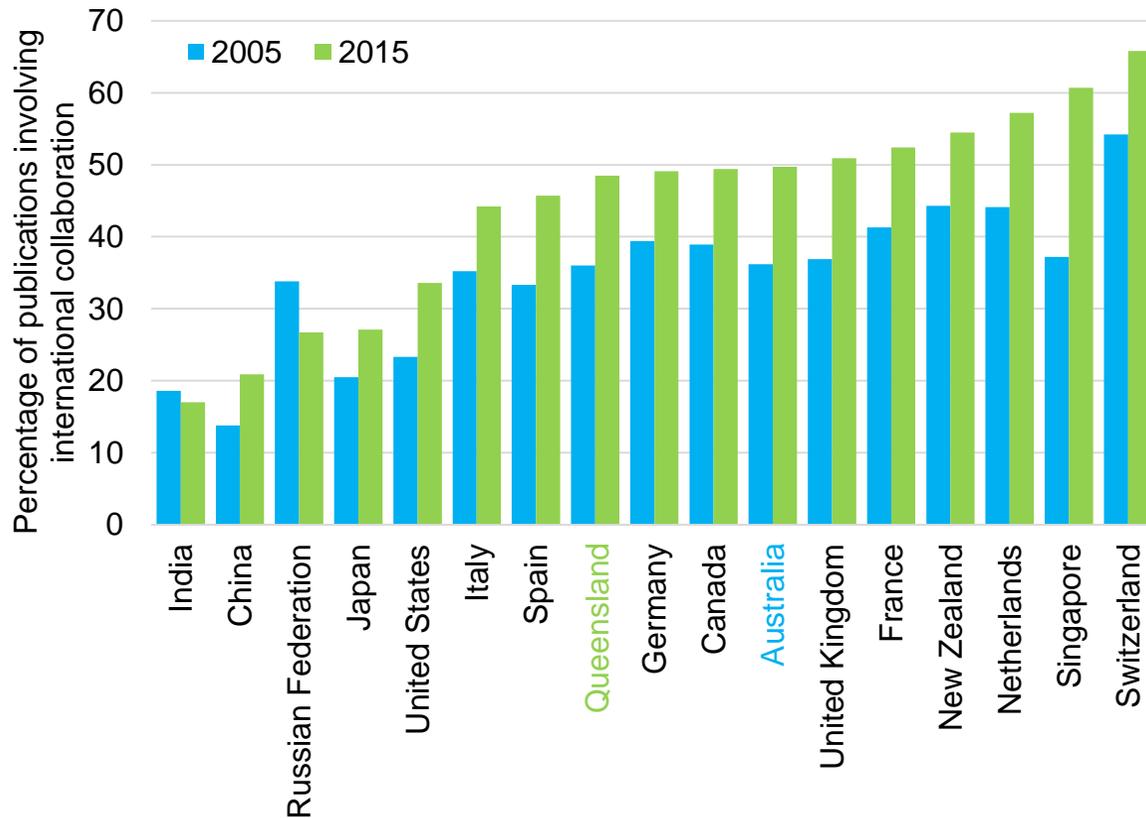
Citation impact is an indicator we can use to examine Queensland's research strengths in greater detail.

Queensland is both internationally recognised and first amongst Australian states in subject areas such as genetics, cellular and molecular neuroscience, applied microbiology and biotechnology (core capabilities for Queensland's biotechnology sector).

In addition, ceramics and composites, biomaterials, applied mathematics, and information systems and management (underpinning the state's vibrant advanced manufacturing and aviation robotics sectors) also rank well.

While Queensland's citation impact is relatively high internationally in fields such as cancer research and plant science, within Australia, we rank only fifth and sixth. This indicates that other states are stronger in these fields than Queensland.

Queensland's international collaboration rate is increasing



A highly collaborative research sector is a healthy research sector that is working and learning from the best. Collaborations also allow us to tap into other's expertise and leverage from their resources.

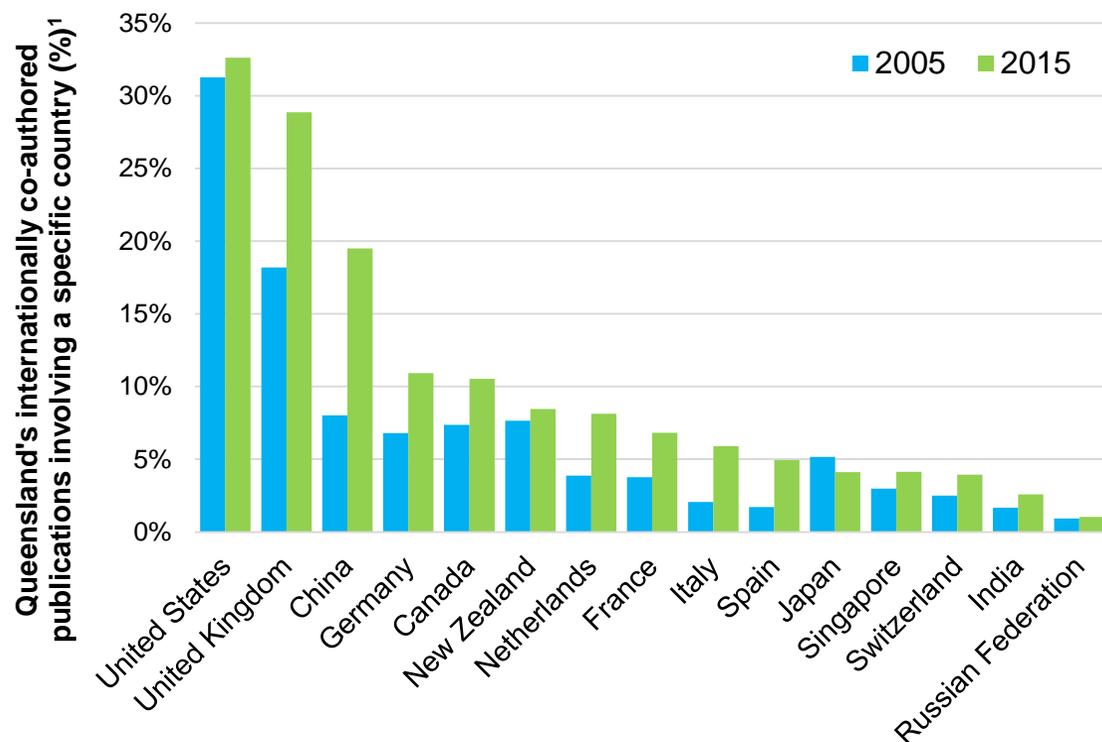
In 2015, 48.5 per cent of publications with a Queensland affiliation also had an author or collaborative institution from overseas.

That figure is similar to the Australian average, but a significant increase on Queensland's position in 2005, when it was 36 per cent. This trend was common to most countries, indicating a global recognition of the critical importance of connection and collaboration in research around the world.

Countries engage in international collaborations where the effort is outweighed by the additional benefits generated. The greater domestic research 'market' of countries like the USA, India and China, means there is less need to go abroad for key capabilities, which is reflected in their lower rates of international collaboration.

Source: Elsevier SciVal (2016)

Queensland collaborations increasingly focus on China



Note: The graph shows the percentage of Queensland international publications with the selected countries, e.g. in 2005, 8 per cent of Queensland internationally co-authored publications involved a Chinese co-author compared to 19.5 per cent in 2015. As publications can involve more than one international partner, the total percentage exceeds 100 per cent.

The pattern of Queensland's collaborations is shifting as researchers identify and link with established and emerging research partners with complementary expertise, capability and resources.

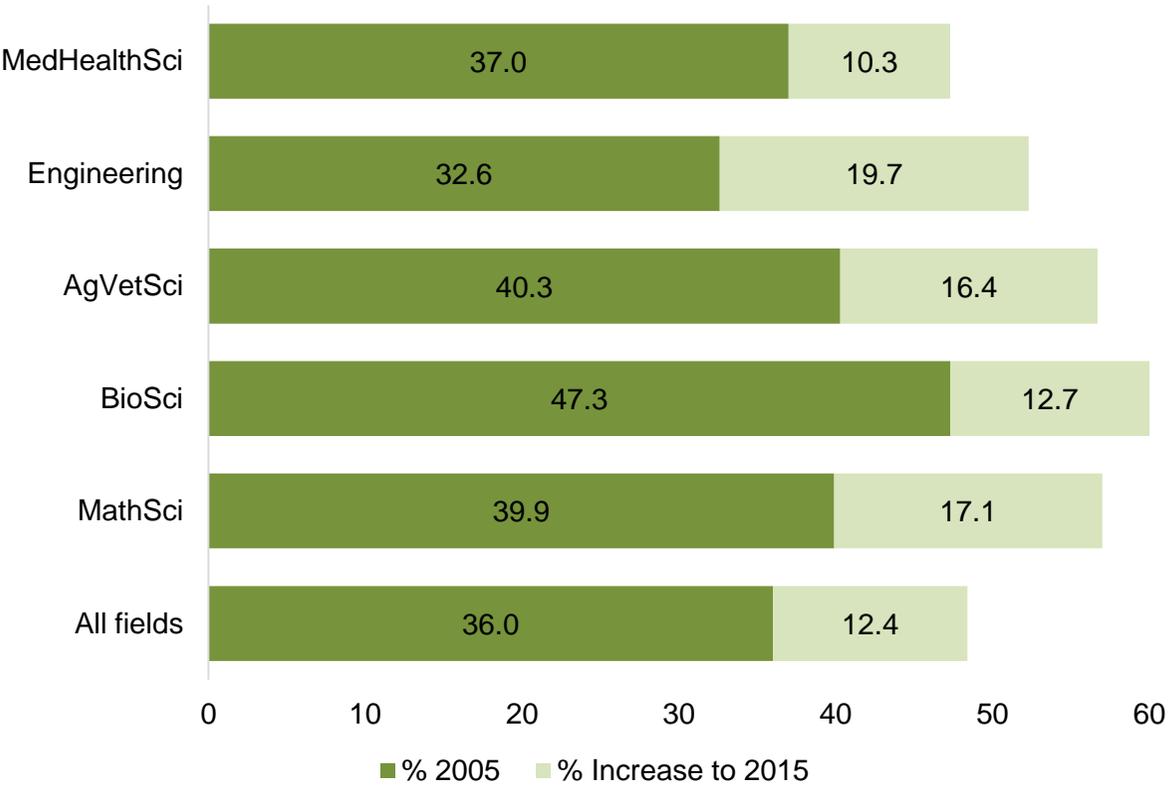
Our links with the United States continue to be strong, reflecting that country's pre-eminent R&D position. However, collaborations with China have been increasing significantly since 2005, a trend which began in the early 2000s. Collaborations with the Netherlands, Italy and Spain have also increased dramatically since 2005.

China's investment in R&D is forecast to be around 77 per cent of the United States total in 2016². However by 2022, thanks to its continued strong economic growth, China is expected to be the world's largest funder of R&D³. China is actively seeking international partners to collaborate on issues such as water supply, energy and agricultural productivity.

In 2008, Queensland signed formal agreements with the Chinese Academy of Sciences and China's Ministry of Science and Technology, underpinned by a targeted joint funding program which has helped profile Queensland as a research partner for China.

Source: 1. Elsevier Scopus (2016) 2. R&D Magazine, 2016 Global R&D Funding Forecast 3. 2014 Global R&D Funding Forecast, www.battelle.org

International collaborations increase across all science fields



Between 2005 and 2015, approximately 60 per cent of Queensland’s publications in biological sciences involved at least one international collaboration. This was the most internationally collaborative STEM field in Queensland.

In 2015 agricultural and veterinary sciences and mathematical sciences had similar collaboration rates and have above average international collaboration rates.

Queensland had a relatively low rate of collaboration in medical and health science, compared to many of the other fields.

Engineering experienced the greatest increase in collaboration rate from 2005 to 2015, increasing from around 33 per cent to 52 per cent of publications involving an international co-author.

Source: Elsevier SciVal (2016)

Performance and collaboration: Observations and recommendations

- Queensland universities are getting better at winning ARC and NHMRC funds but are not doing well in LIEF. Collaboratively focussed funding initiatives like LIEF have a low success rate and in fact Queensland had the lowest rate of all states in 2016. This high failure rate represents not only lost opportunities for Queensland but also wasted time and resources developing and submitting non-competitive applications. Queensland universities are aware of this issue and work is underway to strengthen the collaborative aspect of future LIEF grants.
- Queensland's university research capability is relatively strong in the 2015 ERA rankings as *well above world standard* in eight of the eleven Fields of Research across five of the eight universities. Our key strengths are in environmental sciences and the medical and health sciences field.
- There are some worrying gaps in our capability - agricultural and veterinary sciences has dropped in ranking, while information and computer sciences, a key component of the digital economy, has only one university above world standard - and four universities below. There is also a lack of critical mass in technology capability in the state with only two universities being assessed, albeit at well above world standard.
- While there is significant capability in the medical and health sciences area after the Smart State investment period it is apparent that Queensland has capability gaps. It will be important economically and strategically for Queensland to develop a plan to address critical gaps in capability in consultation with universities, industry, the community and relevant government departments.
- Queensland's collaborative relationships are growing. Collaborating across Australia can be difficult, collaborating with international partners is much harder. Despite the challenges to collaboration, Queensland is increasingly working with international partners, particularly with the United States, the world's leading research power.
- Partnerships with China, facilitated by Queensland's formal government to government agreements are also continuing to develop strongly. International collaboration within research fields varies considerably with biological sciences having the greatest level of collaboration, and engineering showing the greatest increase since 2005.
- Currently there is a funding gap that specifically targets international staff exchanges, travel, fellowships, workshops and access to major infrastructure. This sort of funding would be beneficial for all researchers and would help establish and leverage strategic international partnerships. In particular, this support would benefit regional universities and early-career researchers.

Some highlights

Queensland Government Reef Water Quality Science Program 2009-2015

The Australian Institute of Marine Science's (AIMS) long term-marine monitoring program shows that the Great Barrier Reef's hard coral cover declined by 50 per cent over the 27 years preceding 2012. The causes of this decline were linked to tropical cyclones, coral predation by crown-of-thorns starfish (COTS) and coral bleaching. Unnaturally large COTS populations are linked to increasing loads of nutrients in reef waters, so understanding how to reduce nutrients reaching the reef remains a vital land management priority in the reef's catchments.

The Queensland Government is delivering the Reef Water Quality Science Program. The \$11 million invested since 2009 delivered 50 collaborative reef water quality research projects. The program is now being extended to include projects in other reef catchments including Fitzroy, Burnett-Mary and Cape York.



The full report on the Reef Water Quality Science Program can be found at:
www.qld.gov.au/environment/agriculture/sustainable-farming/reef-program/

The Australasian EQUATOR Centre¹

In April 2016, the Australasian EQUATOR Centre was established at Bond University, joining Centres in Ottawa, Paris and Oxford. The EQUATOR (Enhancing the QUALity and Transparency Of health Research) Network is an international initiative that seeks to achieve accurate, complete, and transparent reporting of all health research studies, which in turn supports research reproducibility and usefulness.

This work increases the value of health research and helps to minimise avoidable waste of financial and human investments in health research projects - a wastage estimated to be over \$100 billion per year. The new Australasian centre will focus on national activities aimed at adoption of good research reporting practices.



The EQUATOR centre at the Centre for Research in Evidence-Based Practice, Bond University, also supports the REWARD group: international collaborative research and initiatives to improve the value of health research - <http://rewardalliance.net/>.

Ellume Respirio Flu Test²

An average of 3500 Australians and up to 500,000 people worldwide die of influenza-related illness each year. However, influenza is treatable with antiviral medicines if administered within 48 hours of infection.

Ellume is a private Queensland company founded in 2010 to deliver innovative diagnostic healthcare solutions to enable people to take increased control of their health and wellbeing. Founder Dr Sean Parsons has developed unique fluorescent immunoassay technology capable of ultra-sensitive detection.

Ellume's first product is the Respirio Flu Test, a world-first non-invasive, single use, ultra-simple test for the detection of influenza in the clinic and in the home. Respirio resembles a nylon handkerchief attached to a digital thermometer, and by blowing their nose into it, determines whether a patient has influenza A or B or no influenza at all.

Respirio will lead to faster diagnosis, containment and treatment of flu. It is currently undergoing clinical trials and is expected to be available for around \$20 in 2017, pending approval.



Some highlights

QUT creates reef-saving robot¹

Queensland roboticists have developed the world's first robot designed to seek out and control the deadly crown-of-thorns starfish (COTS) on the Great Barrier Reef, which are responsible for an estimated 40 per cent of the reef's total decline in coral cover.

Dr Dunbabin built a vision system for detecting COTS ten years ago, but shelved the idea of building a robot due to the limitations of the control methods in use, which required divers to inject each COTS up to 20 times.

Building the robot became possible after a James Cook University breakthrough last year of a one-shot injection method to eradicate COTS.

Dr Dunbabin and computer vision specialist Dr Feras Dayoub will take COTSbot to the Great Barrier Reef to trial it on living targets. In that trial, a human will verify each COTS identification the robot makes before the injection is made.



eAtlas improves management access to knowledge resources²

In response to gaps in environmental research data efficiency, the Australian Institute of Marine Science (AIMS) spearheaded the development of eAtlas – a collaborative, open access data-sharing website and mapping system.

The eAtlas draws on resources from multiple organisations to provide ready access to research data for a range of stakeholders of varying levels of technical expertise. The eAtlas has been designed by AIMS technical experts to digitally capture data, store it in perpetuity and visualise it in an open online mapping environment.

eAtlas has vastly expanded its reach since its inception in 2008 and currently contains data from over 15 institutions, 200 datasets and 3400 mapping layers. It has facilitated the first comprehensive and widely accessible mapping system of the entire Great Barrier Reef, from near Bundaberg to the western edge of the Torres Strait. This visualization tool, and the many other outputs of the platform are fed into national data portals, increasing the exposure and potential use of the data.



Researching crown-of-thorns starfish for the key to population control²



Improving understanding of [Crown-of-Thorns Starfish \(COTS\)](#) outbreaks on the Great Barrier Reef is a high priority across numerous research and management agencies. Through the commitment and investment of multiple partners, the Australian Institute of Marine Science (AIMS) has made progress in delivering the scientific knowledge to inform innovative management and control technologies.

Key achievements to date include better understanding COTS genetics to improve monitoring of COTS populations and novel non-manual control methods. For example, working with a team of international collaborators, AIMS scientists successfully sequenced the complete 'omics' profile of the COTS. Genome scientists can now begin to identify critical vulnerabilities that could be targeted by control technologies, [including scent cues and responses that could potentially play a role in controlling crown-of-thorns starfish.](#)

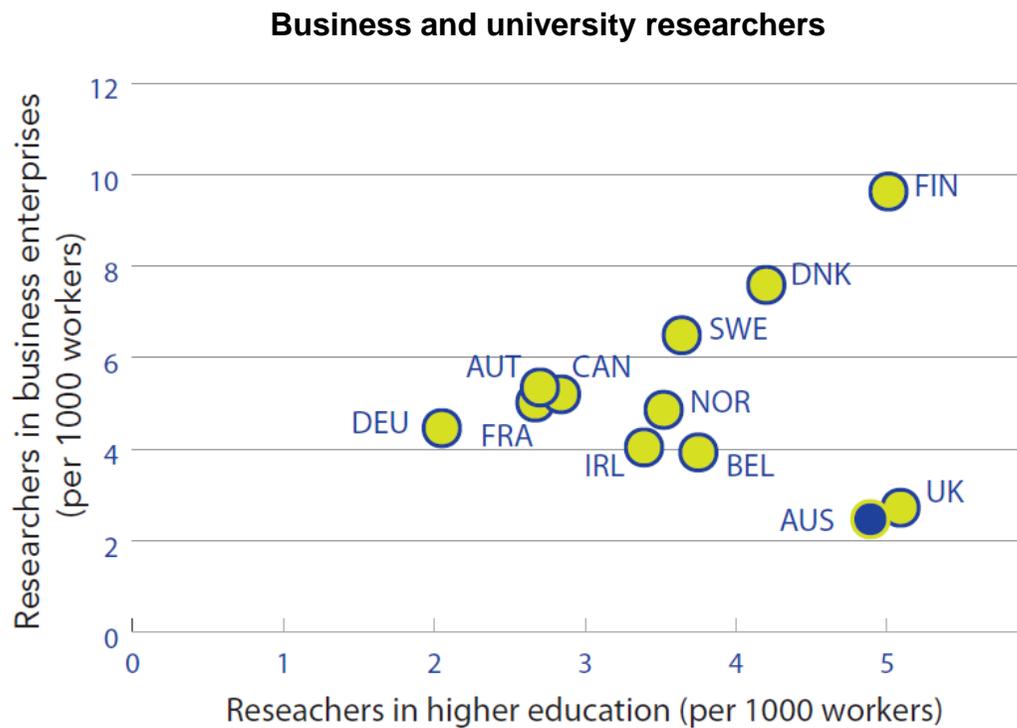
AIMS has long been at the forefront of COTS research. Its [Long-Term Monitoring Program](#) is the only broad-scale observational program documenting the extent and spread of COTS outbreaks across the Great Barrier Reef.

Translation and commercialisation

“The application of what we know already will have a bigger impact on health and disease than any drug or technology likely to be introduced in the next decade.”

Sir Muir Gray, former Director of the UK's NHS National Knowledge Service and NHS Chief Knowledge Officer

Business-research collaboration



“Co-location in knowledge precincts has facilitated authentic, long term engagement between industries and research organisations, with additive manufacturing enabling swift progression from discovery science to prototype, to product in market.”

Professor Ned Pankhurst, Senior Deputy Vice Chancellor, Griffith University

Compared to other Organisation for Economic Co-operation and Development (OECD) countries, Australia’s researchers are much more concentrated in the university sector.

There are almost 2.5 times as many researchers in the university sector than the business sector (about five and two researchers per 1000 workers, respectively).

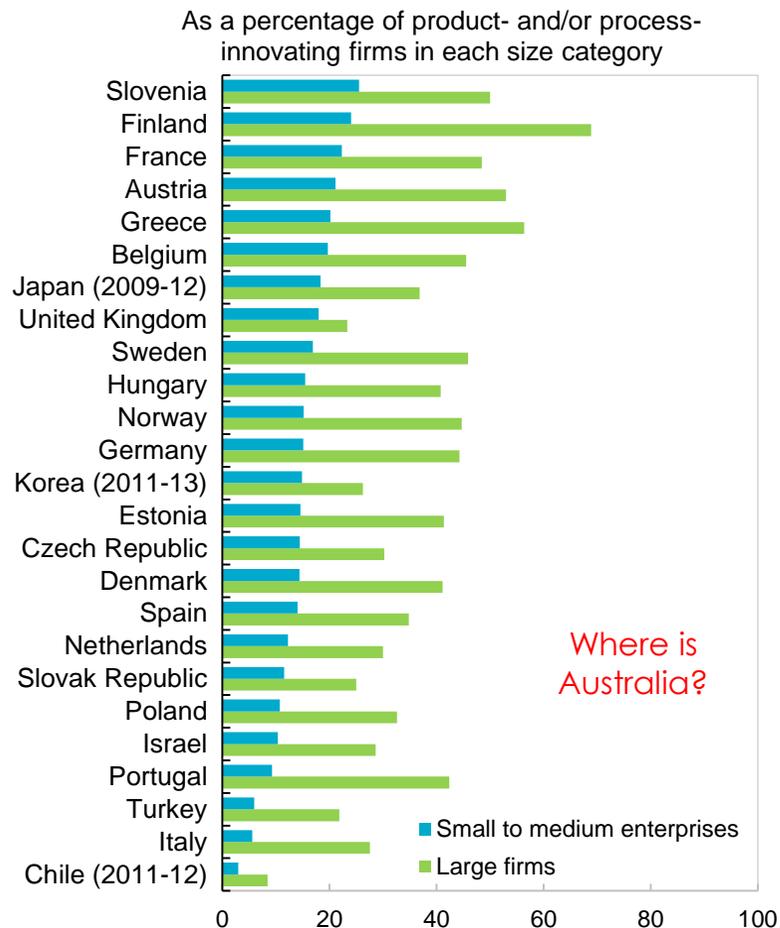
In some countries (such as Finland and Denmark), the ratio is nearly reversed with twice as many researchers in business.

This has significant implications for cross sector communication and collaboration.

Initiatives that encourage greater collaboration between business and research, such as the 50 per cent residency with industry partners/end-users mandated in the Advance Queensland Fellowship programs, will contribute significantly in the push for a much larger cadre of ‘industry savvy’ researchers.

Firms collaborating on innovation

Firms collaborating on innovation with higher education or public research institutions, by firm size, 2015³



While it is clear Queensland has a very solid, and reasonably collaborative, science research base, Australia and Queensland have performed considerably less well in translating that research into commercial and social benefits.

In 2014-15 only 4.8 per cent of innovation-active businesses had a collaborative arrangement with universities or other higher education institutions, down from 9.7 per cent in 2013¹.

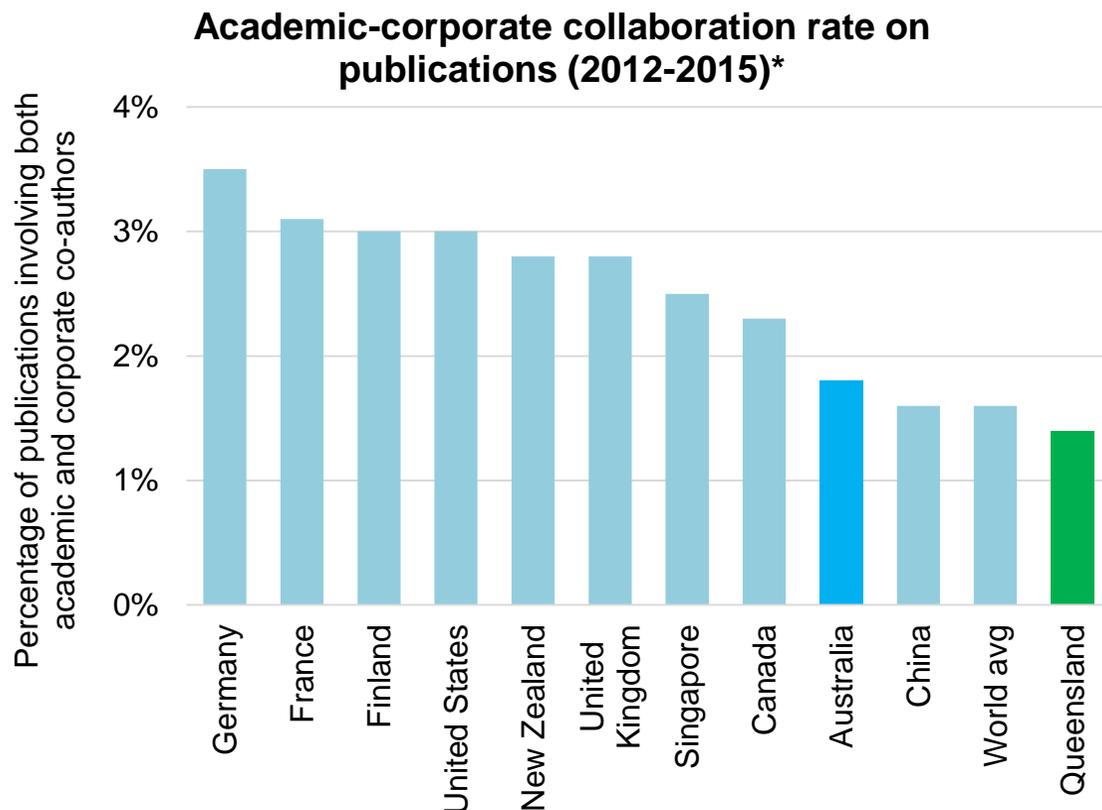
In 2013 the OECD ranked Australia 33rd (last) for innovation-active firms collaborating on innovation with universities and public funded research agencies².

In 2015 Australia no longer appears in the OECD league table of 25 countries. Which may be best given the measures used in the OECD data are based on a European survey and the ABS data is repurposed data from their innovation survey, including an adjustment for firm size.

Is it safe to say 'where is Australia?' or are we obviously still at the bottom of the pack⁴?

Sources: 1. ABS, Innovation in Australian Business, 2014-15, Cat # 8158.0 (released July 2016) 2. OECD Science, Technology and Industry Scorecard 2015 http://dx.doi.org/10.1787/sti_scoreboard-2015-26-en 3. OECD Science, Technology and Industry Scorecard 2015 http://dx.doi.org/10.1787/sti_scoreboard-2015-26-en 4. Industry must drive collaboration July 2015. <http://www.innovationaus.com/2015/07/Wonky-numbers-on-research-collaboration>.

Research-industry collaboration on publications



*There are some issues around data completeness, however Elsevier advises this limitation is likely to affect all comparators equally so it is still useful for benchmarking.

Approximately 1.4 per cent of Queensland's research publications were co-authored by researchers from both academic and corporate, or industry sectors. This is a measure of engagement and knowledge exchange between research and industry.

Queensland's rate of academic-corporate collaboration on publications is below the world average at 1.6 per cent.

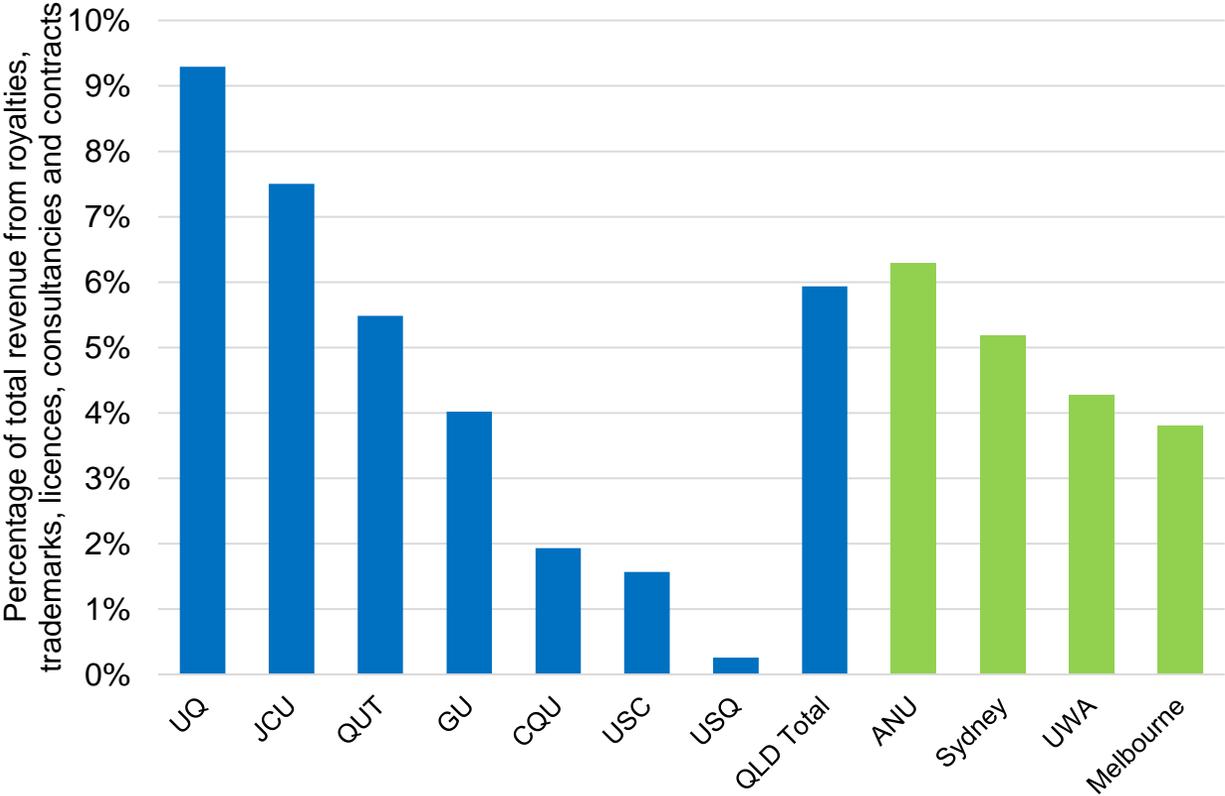
Queensland's poor performance here is relatively unsurprising, given the very low proportion of Australian firms collaborating on innovation with higher education or public research organisations, as shown on the previous slide's OECD league table.

Queensland's rate of academic-corporate collaboration is also below the Australian average of 1.8 per cent. It is possible that Queensland is contributing to the poor performance of Australia in the OECD league table.

Source: Elsevier SciVal accessed July 2016

University income from industry sources

Percentage of total revenue from royalties, trademarks, licences, consultancies and contracts (2014)



“Business in 2030 will see technology integrated into agriculture like never before. Machine vision and robotics will combine to improve farm management in areas such as pest control and crop harvesting.”

Professor Grant Stanley, Deputy Vice-Chancellor of Research, Central Queensland University

As universities develop a greater focus on engaging with industry, industry revenue is expected to represent a greater share of the university’s total income.

Income from royalties, trademarks and licenses is a good indicator of the uptake of university intellectual property, derived by R&D, by industry.

At least three of our Queensland universities appear well engaged with industry and receive a high percentage from this revenue stream compared to some of the interstate universities.

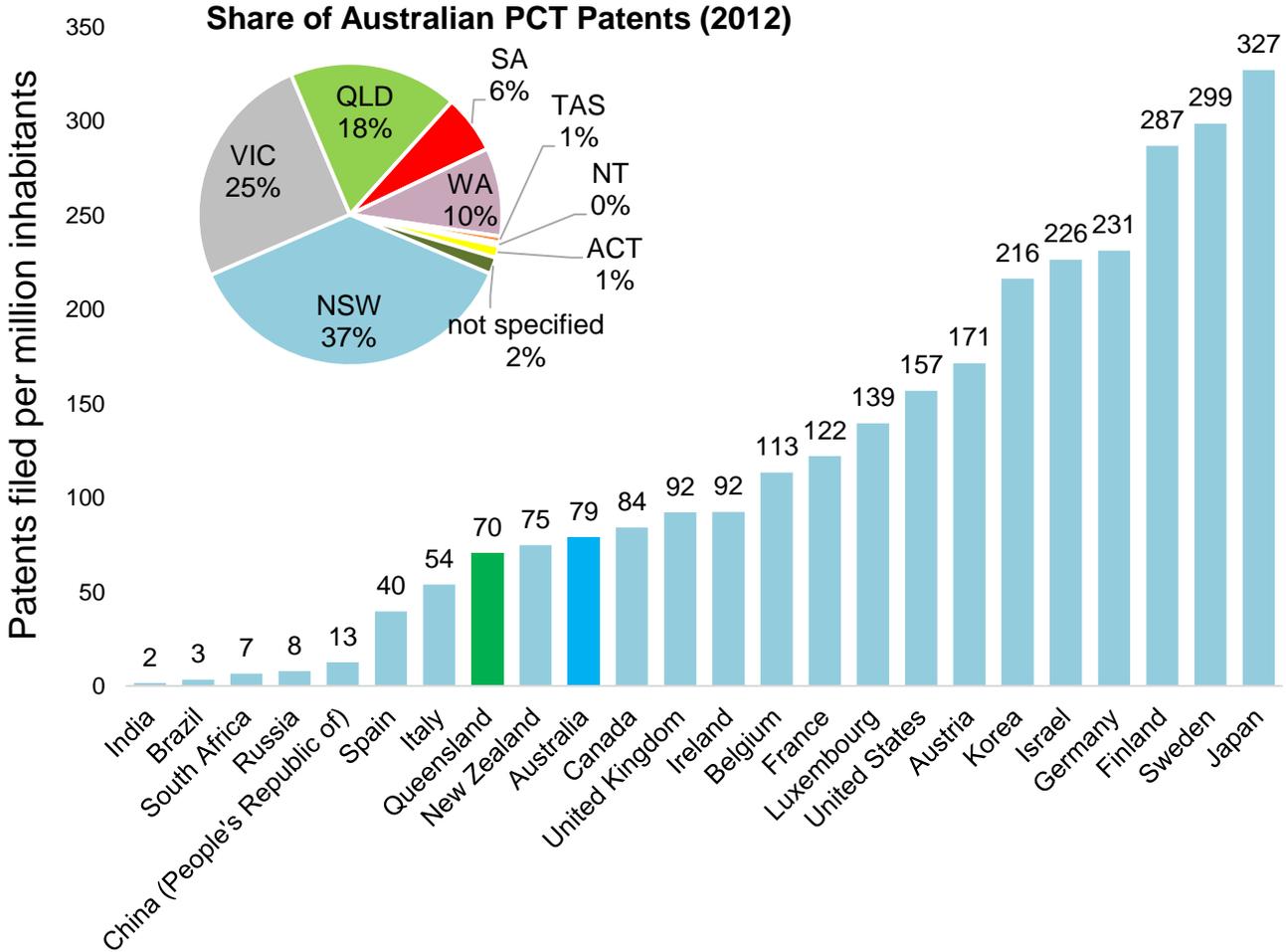
It has been suggested that in the university system, the majority of industry income is sourced from just a handful of large industry players, however some universities report a broader income base. So while the revenue stream appears high the number of firms collaborated with is not comparative.

Additionally this measure takes much of its input from consultancies and contracts - this type of collaboration is often one-way knowledge transfer.

Source: Australian Government, Department of Education and Training, Finance Publication 2014 <https://docs.education.gov.au/node/38416>.

Patenting performance

Patents filed under the Patent Cooperation Treaty 2012 (latest available data)



Patenting performance provides a partial measure of the potential for research to be translated into commercial and practical benefit.

There is a very broad range of patenting performance per head of population under the Patent Cooperation Treaty (PCT), ranging from India at 2 applications per million people to Japan with almost 330.

There have been some significant shifts since 2011, with New Zealand moving up five, leapfrogging Australia, and Germany increasing by 11. By contrast Israel dropped two.

Queensland is a relatively poor performer with 70 applications (under the Patent Co-Operation Treaty) per million population - slightly below the Australian average (79 per million)^{1,2}.

The most active nations in this measure file more than 250 patents per million of population^{1,2}.

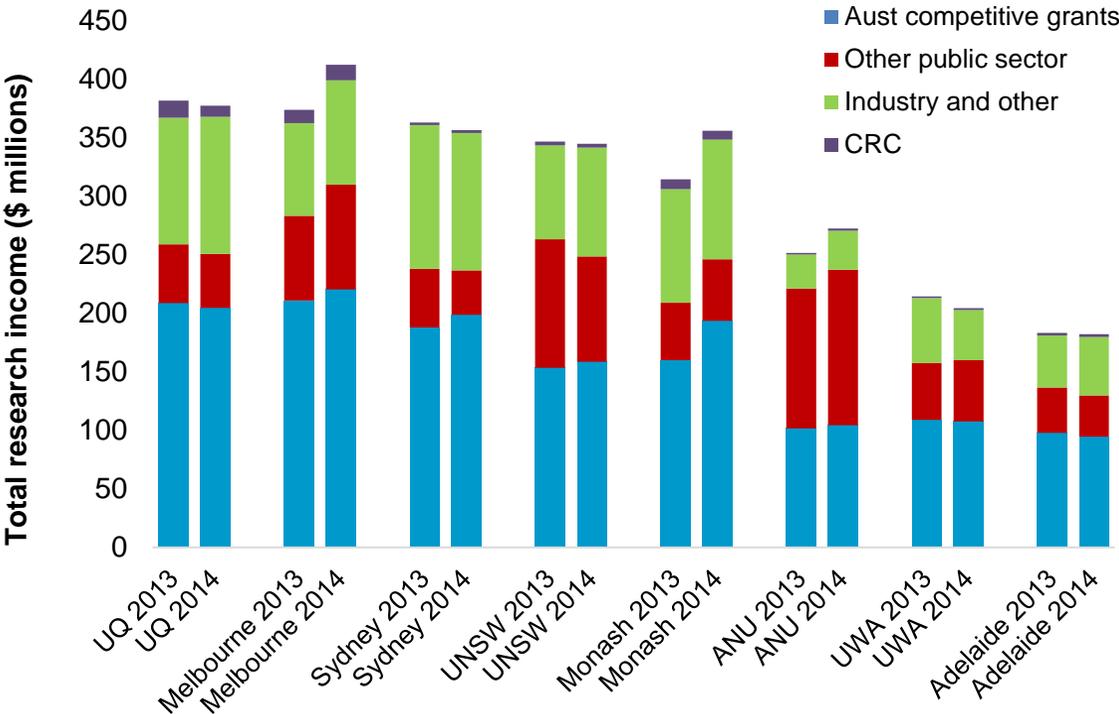
Sources: 1. OECD Patents Statistics (Patents by regions) 2. OECD, Demography and Population Statistics (Population)

Group of Eight research income

Total research income from The University of Queensland (a 'Group of Eight Research Intensive University') grew steadily from 2008 to 2013, but decreased slightly in 2014¹. This decrease was due to receiving less competitive grant funding, other public sector funding and Cooperative Research Centre (CRC) funding.

In 2014, the total research income from UQ was slightly lower than that of The University of Melbourne and greater than all other Group of Eight universities.

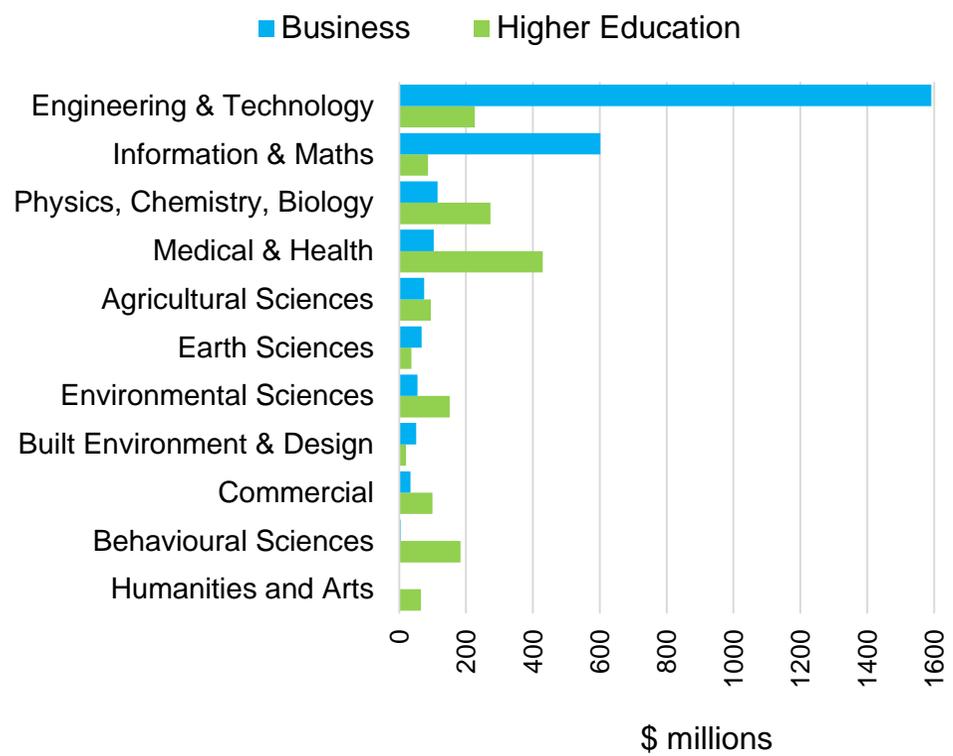
In 2014, the majority of research income was sourced from Australian competitive grants².



Sources: 1. Group of Eight (2015) <http://www.mis.admin.uq.edu.au/Content/Dashboards/GroupofEightExecutiveDashboard/Research.aspx> 2. Australian Government (2015), 2014 Research income and publications data by sub category. Department of Education <https://docs.education.gov.au/node/39111>

Business and university spending on R&D

Business and Queensland university R&D spend (\$)



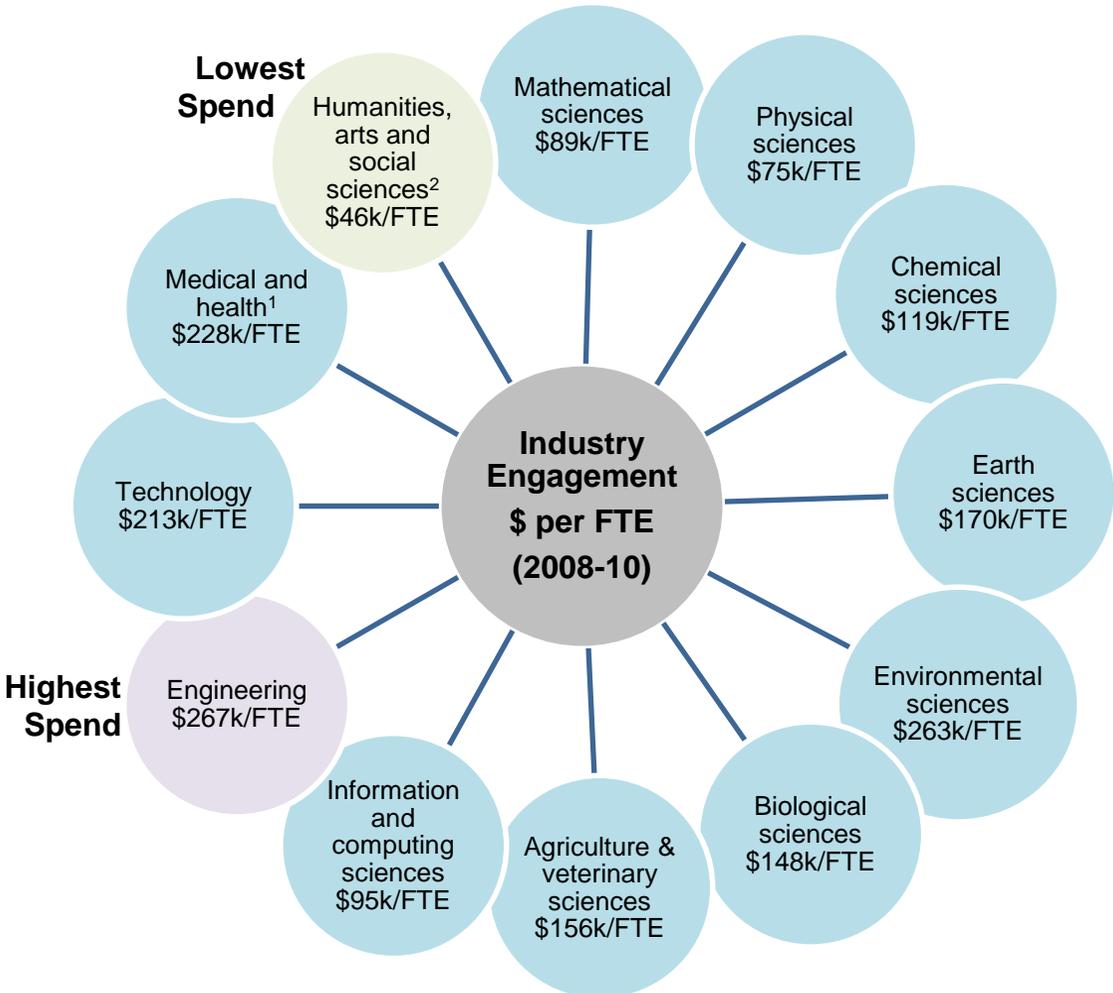
Compared with businesses Australia-wide, Queensland businesses have a high proportion of investment in the following fields: earth sciences, built environment and design, environmental sciences, engineering and mathematical sciences. By contrast, compared with universities elsewhere in Australia, Queensland universities have elevated activity in the following fields: environmental sciences, technology, agricultural and veterinary sciences, and biological sciences.

Interestingly, there is overlap here in relation to one of these areas, agricultural Sciences. However, the proportion of Queensland university investment in earth sciences and in built environment and design is surprisingly low relative to that in university systems in other states.

This confirms that some of the patterns observed previously (as shown in HOQS 2014) persist and that there continues to be a mismatch not just by volume of investment in different fields across the two sectors, but also when one benchmarks the foci within different sectors against other states (Barlow, 2016).

Source: Barlow, T. 2016 commissioned analysis for the Queensland Chief Scientist. Data obtained from the Australian Bureau of Statistics, Cat. No. 81040DO001_201314 Research and Experimental Development, Businesses, Australia, 2013–14 (released 4 September 2015) and the Cat. No. 81110DO001_2012 Research and Experimental Development, Higher Education Organisations, Australia, 2012 (released 20 May 2014)

Industry engagement by Queensland universities



Research engagement involves knowledge exchange between researchers and industry or other groups, which can include formal partnership arrangements and resource sharing.

A recent pilot conducted by the Australian Academy of Technological Sciences and Engineering (ATSE), used income received from industry as a measurement for research engagement, as this information was readily available.

Research engagement per full time equivalent (FTE) measures the quantum of research engagement income attracted in a Field of Research (for all Queensland universities), divided by the sum of Queensland's FTEs in the respective Fields of Research. This provides a partial productivity measure that is adjusted for the number of university researcher FTEs in a discipline in Queensland.

Significant and beneficial research engagement can occur without being linked to industry funding, particularly in humanities disciplines. Regionally focussed engagement, particularly important to Queensland's regional universities, is also important for harnessing local expertise and knowledge.

This data is based on raw totals for research engagement income and this diagram is a quantitative representation of activity for each field of research. Comparisons should not be made between fields of research as each has a different baseline of activity.

1- Includes: Medical and Health Sciences; and Psychology and Cognitive Sciences

2- Includes: Built Environment and Design; Education; Economics; Commerce, Management, Tourism and Services; Studies in Human Society; Law and Legal Studies; Studies in Creative Arts and Writing; Language, Communication and Culture; History and Archaeology; and Philosophy and Religious Studies

Source: Department of Science, Information Technology and Innovation analysis on Research Engagement for Australia: Queensland Universities Report, Australian Academy of Technological Sciences and Engineering (2015)

Translation and commercialisation: Observations and recommendations

- In contrast with many of the world's leading innovative economies, like Finland and Denmark, Australian researchers are located predominately in the university sector. The low proportion of Australian researchers working in industry has implications both for uptake and application of new research findings, but also for the identification of applied research priorities.

It is important that we encourage and create policy settings that place university graduates and researchers in industry to foster a productive research environment.

- This should include short-term industry placements as part of the professional development of early- to mid-career researchers; maintaining a minimum industry placement as a mandatory criteria for any government research fellowship programs; and developing and implementing an entrepreneurship component as part of all undergraduate degrees to instill an entrepreneurial perspective in all university students.
- In 2015, only 4.8 per cent of Australian innovation-active businesses were collaborating with universities and public research agencies, almost half that in 2013. In 2015, Australia was no longer included in this measure, being outcompeted by countries like Chile and Portugal.
- Joint publications represent one way to categorise collaborative relationships with industry partners as all parties have a shared interest in the underlying research. Queensland's rate of joint publications falls below that of

Australia and below the world average. Our universities also engage with industry through contracted research or consultancies, which are also a mechanism to share information and build networks between universities and businesses.

- Queensland businesses and universities do not share R&D investment priorities. Business R&D was highly focussed, with the lead area being engineering and technology while university R&D was more broad-based however the lead was the medical and health domain. As stated in HOQS 2014, *"While it is not expected nor desirable for these sectors to be fully aligned, we need a greater understanding between the two groups to improve communication, collaboration and research translation."*
- Ideas need a diverse, vibrant and collaborative research sector with the right people, infrastructure and funding to flourish. We need to collaborate - across countries, subjects and sectors - to address future challenges and maximise our investments.

Whilst we create initiatives to address the flow of ideas from the universities into businesses, we should keep in mind - this is a two-way street and the business sector needs to be more involved if we are to improve communication, collaboration and research translation.

Some highlights

Australian Institute for Bioengineering and Nanotechnology Spinifex Research¹

Professor Darren Martin at the Australian Institute for Bioengineering and Nanotechnology (AIBN) has developed a method of extracting nanocellulose from spinifex grass, which is being applied to significantly improve the physical properties of latex products.

This research was developed in partnership with the Indjalandji-Dhidhanu people, the traditional owners of the Camooweal region in north-west Queensland. They historically used spinifex resin in medicines and as a glue. The partnership is an example of combining traditional knowledge with modern scientific advancements to achieve new research breakthroughs with potential commercial outcomes.

This scientific breakthrough has been leveraged from over \$63 million of previous Queensland Government investment in AIBN. Prof Martin's team was recently awarded two competitive research grants through Advance Queensland. Dr Pratheep Kumar Annamalai received an Advance Queensland Research Fellowship (mid-career) to research the application of spinifex to construction materials and Dr Nasim Amiralian received an Advance Queensland Research Fellowship (early-career) to research the advancement and commercialisation of spinifex enhanced rubber products. Dr Amiralian's achievements in this area were recently recognised through the Women in Technology Life Sciences/ICT Rising Star Award.

Scientifically proving 'Super-foods'²

Eminent pharmacologist, Professor Lindsay Brown leads the University of Southern Queensland's Functional Food Research Group (FFRG). FFRG are providing the foundation for the development of scientifically proven 'super-foods' that deliver optimal health benefits and significantly reduce the risks associated with chronic 'lifestyle' diseases. Their research investigates the potential for functional foods, including Queen Garnett plums, purple carrots and seaweeds, chia seeds, ellagitannins, and cardamom, to reverse human obesity and chronic inflammatory diseases.



Queen Garnett Plum

Professor Brown works with Advance Queensland Fellow, Dr Sunil Panchal and other members of his research group to investigate the effects of functional foods on metabolic and inflammatory diseases using to appropriate rat models. FFRG is now moving towards the beginning of human intervention trial with functional foods.

Most recently, the Group's tests involving the Queen Garnett Plum discovered that rats fed the plum's juice returned to their normal body weight and that damage to their hearts and livers was reversed, due to the exceptionally high levels of anthocyanin - a chemical compound with exceptional anti-inflammatory agents.

Building identity and cyber crime resilience³

Identity theft impacts over 300,000 Queenslanders and over 1.5 million Australians each year. IDCARE's (Australia and New Zealand's National Identity and Cyber Support Service) National Identity Lab is co-located at the University of the Sunshine Coast is working with investigators on a significantly growing threat to the community. Partner organisations include the Department of Foreign Affairs & Trade, the Department of Human Services, the Queensland Police Service, the Queensland Registry of Births, Deaths and Marriages and nineteen other organisations that play a vital role across the Australian identity ecosystem.

The research has led to enhanced ways organisations prevent and respond to identity and cyber crime in Australia and abroad. This research continues to build strong momentum, attracting visiting academics nationally and abroad, and in the past 12 months has won Australia's Best New Cyber Security Initiative 2016 at the Australian Cyber Security Awards and Queensland Police's 2016 Partnership Award.

David Lacey with research partner Detective Acting Superintendent Terry Lawrence of the Queensland Police Fraud & Cyber Crime Group.



Some highlights

Institute for Molecular Bioscience inflammatory disease treatment receives global investment of up to \$22m¹

Researchers at UQ's Institute for Molecular Bioscience have developed a small molecule that blocks a key driver of inflammatory diseases. The discovery has created opportunities for the development of new treatments for disorders such as Parkinson's disease and asthma. A finding that has led to an investment of up to \$22m from top tier international investors.

Working with researchers at Trinity College Dublin, the research led to the formation of startup company, Inflazone Ltd and the successful closing of a Series A financing round of up to €15 million (A\$22 million).

The investment, co-led by two top leading global life science investment firms, Novartis Venture Fund and Fountain Healthcare Partners, is one of the largest biotech Series A investments in Australia. It is the latest in a recent series of international commercialisation deals based on UQ research.

The intellectual property is based on work by UQ Institute for Molecular Bioscience researchers Professor Matt Cooper, Dr Kate Schroder, Dr Rebecca Coll and Dr Avril Robertson; in collaboration with Professor Luke O'Neill at Trinity College Dublin.

Malaria breakthrough offers hope for cure²

Scientists at QIMR Berghofer Medical Research Institute have developed a protein which completely cures mice of malaria and protects them against re-infection. The breakthrough could lead to a new and more effective way of treating the deadly disease in future.

The findings were published recently in the prestigious journal Immunity.

Malaria is caused by parasites that are spread to humans by the Anopheles mosquito. According to the World Health Organisation (WHO), the disease killed an estimated 438,000 people in 2015. Most deaths are in young children and unborn babies. The WHO estimates that nearly half of the world's population is at risk of the disease.

The head of the Molecular Immunology laboratory at QIMR Berghofer, Dr Michelle Wykes, and her team discovered that a protein on the surface of a particular immune cell plays a crucial role in fighting malaria infection.

The research involved collaborators from the University of Queensland's Institute for Molecular Bioscience and School of Chemistry and Molecular Biosciences; The Queensland University of Technology; Singapore's Agency for Science, Technology and Research; and, Harvard Medical School in the United States.

Industry collaboration creates greener concrete³

James Cook University (JCU) scientists have teamed up with Queensland company Fibercon to develop fibres from industrial plastic wastes to reinforce concrete, reducing the carbon footprint of construction at no additional cost. The result is Emesh, a robust, durable and crack-resistant concrete product strong enough to replace steel mesh in concrete footpaths.

Environmentally-friendly products are often more expensive than traditional alternatives, but with Emesh that's not that case. The product is either cost neutral or offers cost and time savings compared to steel-reinforced concrete. Using recycled plastic fibres in concrete also reduces the plastic waste that goes to landfill and helps to decrease the carbon footprint of construction.

This 'greener concrete' was developed as part of PhD student Shi Yin's research under Dr Rabin Tuladhar's supervision at JCU. The research team led by Dr Tuladhar recently won the Manufacturing, Construction and Innovation category at The Australian Innovation Challenge. The next phase of research will further enhance the mechanical and bond properties of plastic fibres using surface modification.



Left to Right: Tony Collister, Fibercon; Shi Yin, JCU; Rabin Tuladhar, JCU and Andrew Smith, Country Chair Shell.

Innovation and startups

“If only Australia knew what Australia knows.”

Catherine Livingstone AO, President, Business Council of Australia and formerly Chair of the Board of Telstra and CSIRO.

Supporting innovation and startups

There is a pathway along which pure and applied research are used to create proof-of-concept models that may be further developed and commercialised, often via seed funding or startups, into products and services which we all may use and benefit. This translation process requires a strong base of research, innovation, and entrepreneurship, as well as the culture and will to succeed.

Past investment by the Queensland Government has focussed on developing a critical mass of researchers and infrastructure in priority areas of expertise. The \$405 million Advance Queensland initiative builds on this base by emphasising the need for translation and commercialisation of our R&D efforts into products and services. Advance Queensland is developing innovation capacity through programs which broker connections and collaborations, increase investment, support a dynamic culture which scales across regions, industries and communities.

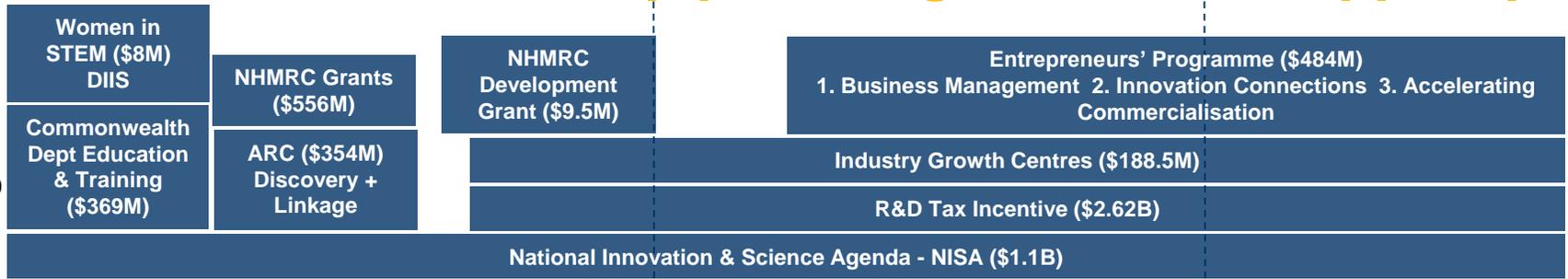
The Commonwealth Government has also made a significant investment in research and innovation programs from which Queensland research providers and firms have benefitted. Offerings are made by entities/initiatives such as the Australian Research Council, Entrepreneurs' Program, R&D Tax Incentive, and the National Innovation & Science Agenda.

The relatively recent introduction of programs by both the Queensland Government and the Commonwealth Government has now led to a much more balanced approach for supporting the entire length of the commercialisation pathway (refer to figure on the next page), with a greater focus on the 'D' component of 'R&D' to translate our research into commercially-available goods and services.

Although there is significant overlap between Advance Queensland and the innovation and entrepreneurship programs on offer by the Commonwealth, this is no accident – both programs share similar policy goals in creating the right environment for success. Paramount is creating the jobs for the future, with a STEM-based workforce at the forefront of developing new technologies. This new emphasis on innovation, entrepreneurship, and the 'D' component of 'R&D' will increase the chances of translation of our research and the commercialisation into goods and services.

Research and innovation pipeline - government support programs

Commonwealth Programs

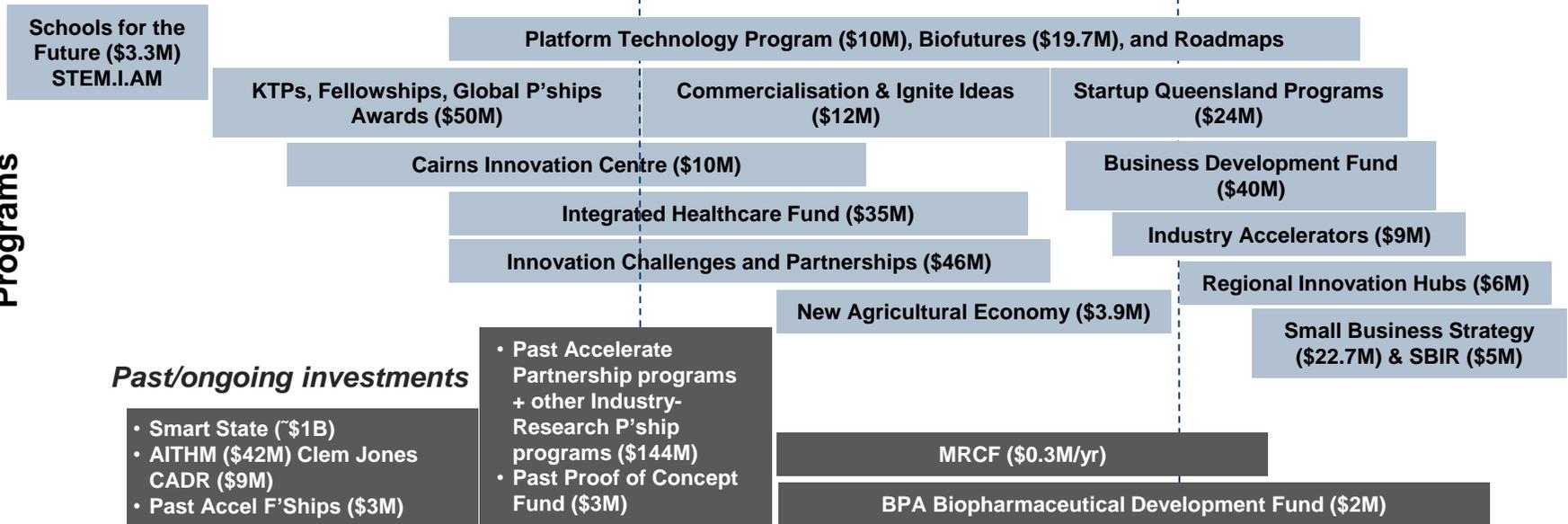


Jobs
Skills
Productivity
Better environment
Lifestyle
Healthier living



Advance Queensland & Accelerating Advance Queensland (\$405M)

Queensland Government Programs



Our businesses don't collaborate well, but leaders want to...



Believe their firm would innovate better by partnering than on their own

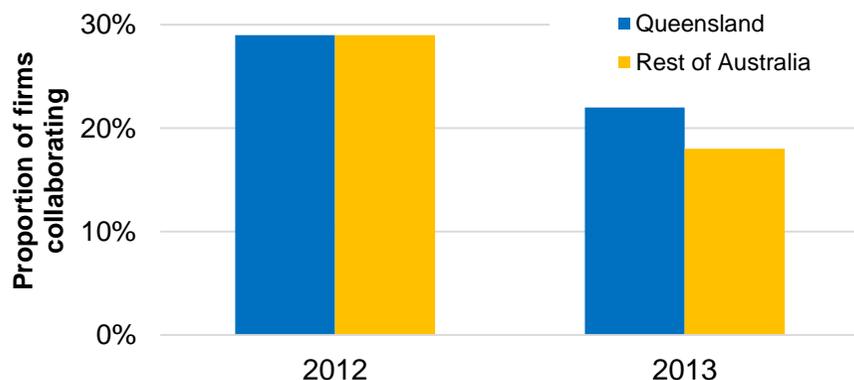


Have actually developed a new product, improved a product or created a new business model through collaboration with another company.

In a survey of more than 3100 business leaders from 25 countries around the drivers of innovation, 87 per cent believed their firm would innovate better by collaboration¹.

Sixty-eight per cent of business leaders reported that their firms had actually developed a new product or created a new business model through collaboration with another company¹.

Queensland business collaboration (three year levels - weighted)²



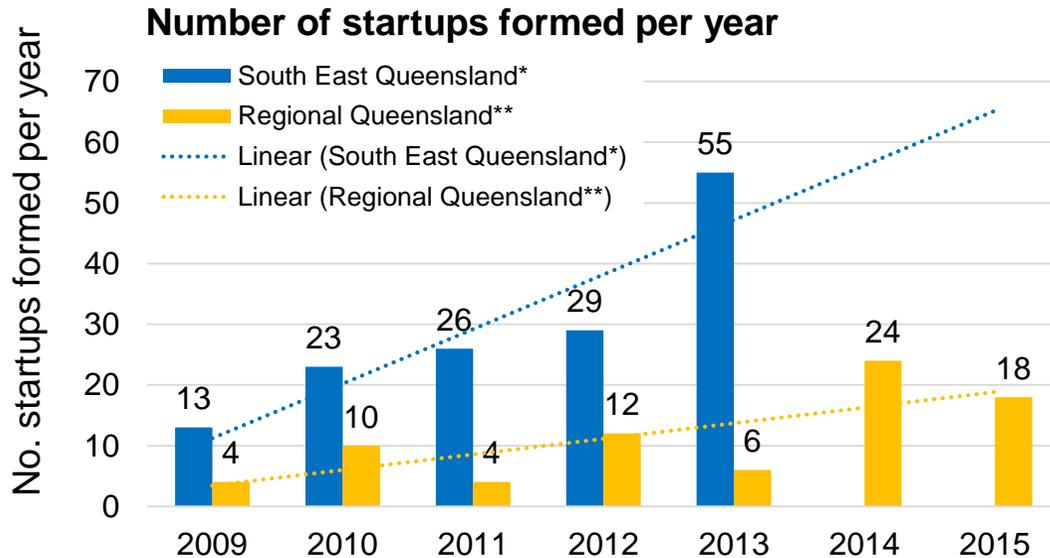
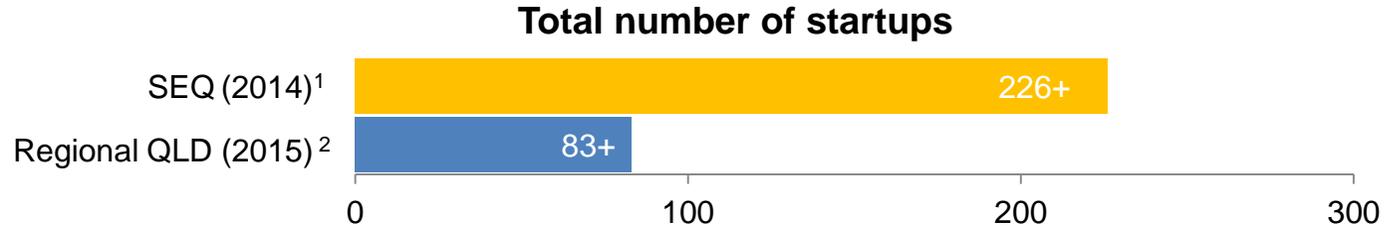
*This chart is based on a survey² of 1,566 Australian firms representing 0.07 per cent of total Australian firms. The figures in this dataset are estimates and will exhibit, in some cases, large volatility.

The rate of collaboration for Queensland business (collaborative or partnership arrangements during the three years to December 2013) was lower than levels recorded in a previous survey^{2*}.

Networking and collaboration are fundamental to any innovation system. Business collaboration on innovation is significantly and positively associated with new-to-market innovation - leading to a 70 per cent increase in the chance of achieving new-to-world innovation³.

Source: 1. Harary, A., and Pulizzi, U. (2013) GE global innovation barometer. Third edition, January 2013. Report commissioned by GE to StrategyOne. https://www.ge.com/sites/default/files/Innovation_Overview.pdf 2. Verreynne, M-L. and Steen, J. (2014) Queensland Business Innovation Survey 2014 Report. UQ Business School for the Queensland Government <https://www.qld.gov.au/dsiti/assets/documents/qld-business-innovation-report-2014.pdf> 3. Australian Innovation System Report 2014, <http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/Australian-Innovation-System/Australian-Innovation-System-Report-2014.pdf>

Where are Queensland's startup entrepreneurs?



* Data available as at July 2014¹.

** Data available at time of 2015 report publication. Regions include: Cairns, Townsville, Mackay, Rockhampton, Bundaberg, Ipswich, and Toowoomba².

Note: Number of startup companies founded by calendar year does not equal the total number of startups as the founding dates for some startups were not identified.

There is a real and substantive opportunity for the startup sector within Queensland to grow and play a much larger role in the local, national and international economy¹.

Applications to the Advance Queensland Startup Queensland program have clearly demonstrated pent-up demand and enthusiasm: as of October 2016 118 applications have been received to the Startup Events and Activities Fund, 114 to the Startup Attraction program (Hot DesQ) and 57 to the Young Starters Fund.

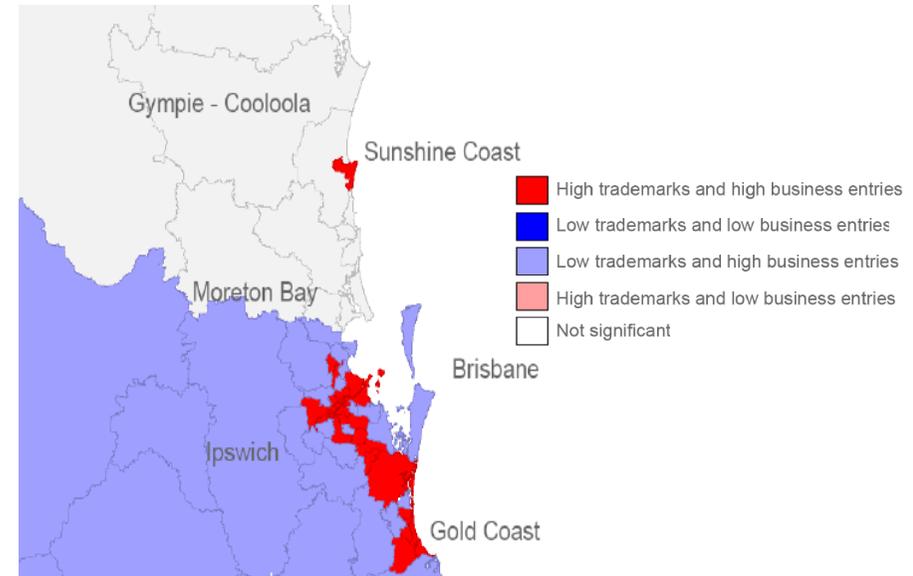
US technology hubs have yearly startup formation rates per million people ranging between 97 to 256. Queensland's current rate is 12².

Sources: 1. Kruger, M., and Cacioppe, J. (2014) South East Queensland 2014 startup ecosystem report Boundlss on behalf of the Queensland Government <https://www.qld.gov.au/dsiti/assets/documents/startup-ecosystem-mapping-report.pdf> 2. Markham, N., Kruger, M., and Cacioppe, J. (2016) Regional Queensland 2015 startup ecosystem report. Boundlss on behalf of the Queensland Government, January 2016 <https://www.qld.gov.au/dsiti/assets/documents/regional-qlld-startup-ecosystem-report.pdf>

Queensland - the most entrepreneurial state in Australia?

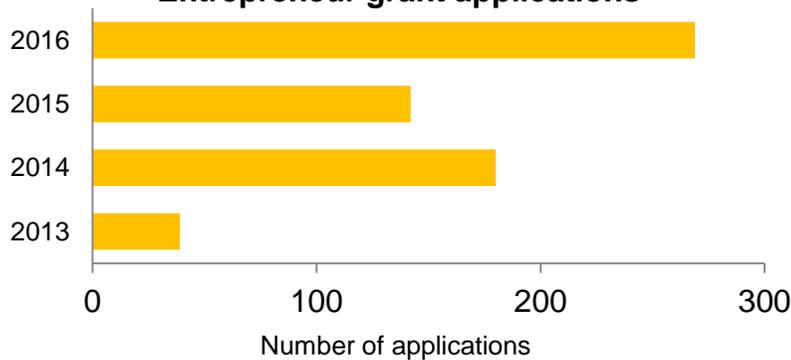
The Australian Innovation System Report 2015 reported that Brisbane, Gold Coast, and Sunshine Coast are important regional areas of innovative entrepreneurship as they display a correlation between the presence of research institutions with innovation activity (patents, trademarks) and the generation of new businesses, especially in professional, scientific and technical services¹.

The report also stated that “*The corridor of industries stretching from the Sunshine Coast, through Brisbane to the Gold Coast results in Queensland having a more even spread of innovative entrepreneurship than any other state in Australia. Along with the high per capita business entries in less populous central and western Queensland, it might be said that Queensland is the most ‘entrepreneurial’ state in Australia.*”¹



Source: Australian Innovation System Report 2015 (Fig. 4.1)¹

Brisbane Lord Mayor’s Budding Entrepreneur grant applications²



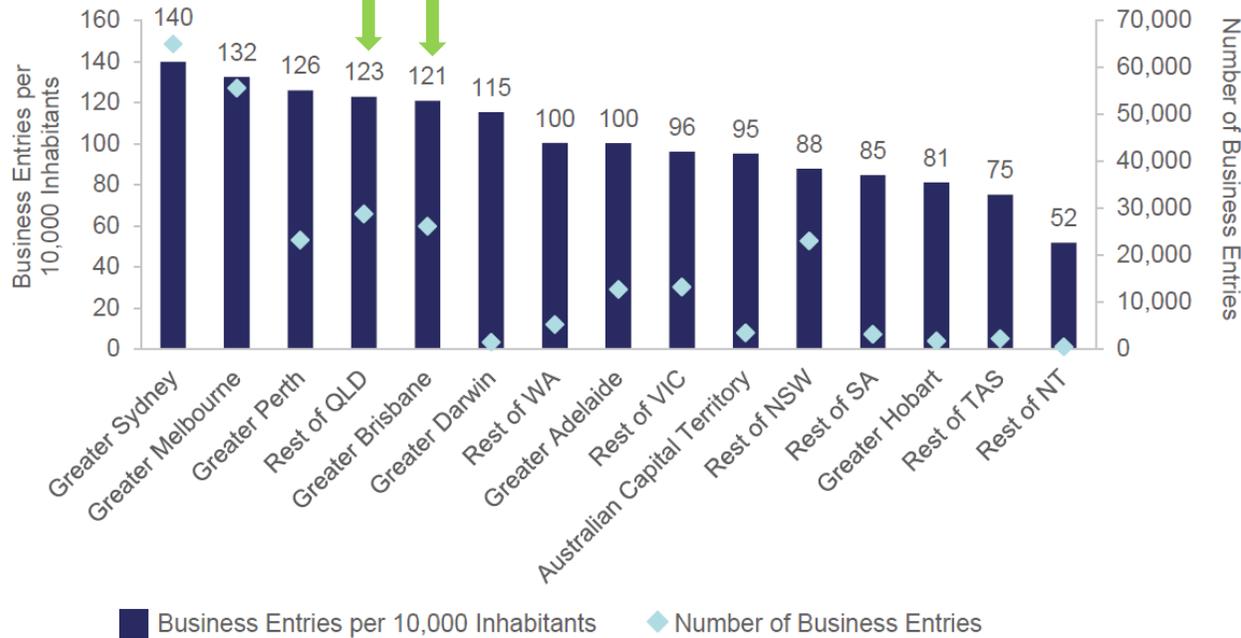
Contributing to this startup culture is the Brisbane Lord Mayor’s Budding Entrepreneur grant program which has seen a steady increase in interest since its inception in 2013. The Lord Mayor’s Budding Entrepreneur grant program is an initiative of the Digital Brisbane strategy².

Source: 1. Office of the Chief Economist (2015) Australian Innovation System Report 2015 Department of Industry, Innovation and Science, Australian Government, November 2015 <http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/Australian-Innovation-System/Australian-Innovation-System-Report-2015.pdf> 2. Personal communication, Cat Mastson, Brisbane Marketing Re: Lord Mayor’s Budding Entrepreneur Grants program.

Businesses in Queensland

New business entries

(2009 to 2014)



New business entries, i.e. businesses that are new to the market, are a proxy measure of entrepreneurial activity.

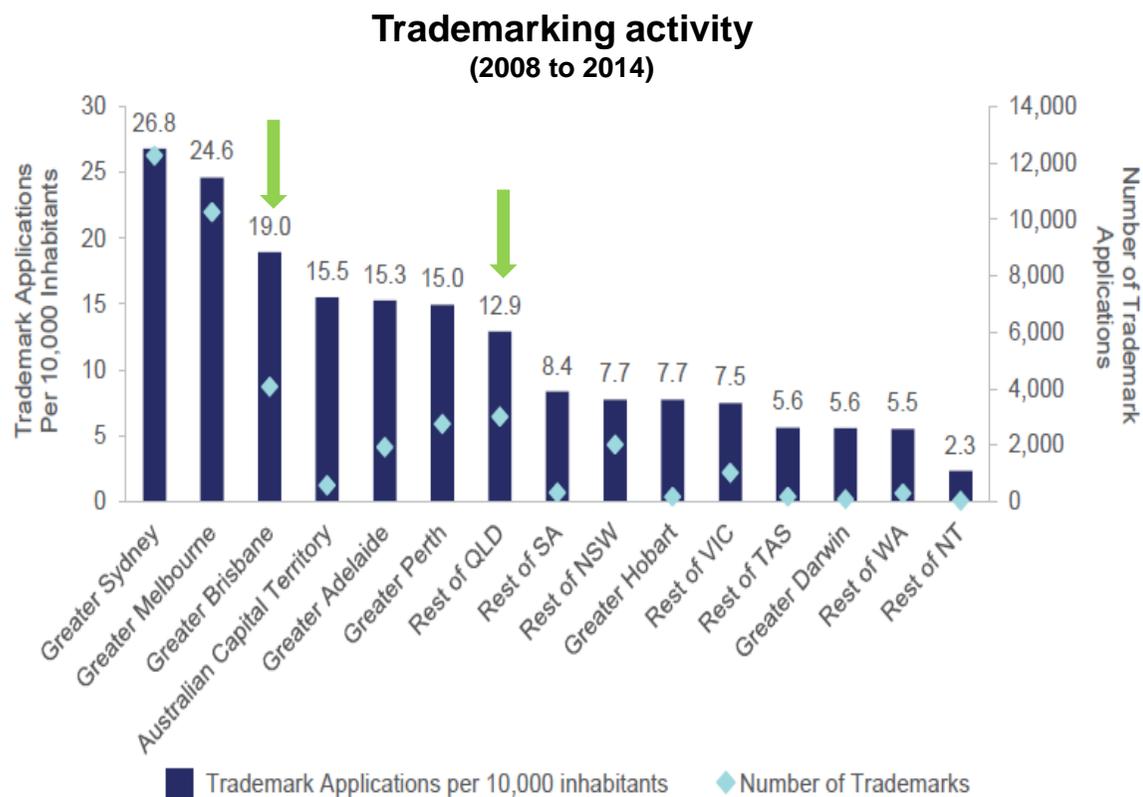
The regional areas of Queensland, followed closely by Brisbane, have the fourth and fifth highest rate of new business entries per capita in Australia¹.

Most entrepreneurs around the world are motivated to start their business by opportunity (78% in innovation-driven economies), rather than necessity².

However, the reasons for exits are multifarious, and for Australian businesses rank (out of 60 surveyed countries) as follows: another opportunity (1), sale (11), personal (30), bureaucracy (39), or finance (54)².

Source: 1. Australian Innovation System Report 2015 <http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/Australian-Innovation-System/Australian-Innovation-System-Report-2015.pdf> 2. Kelley, D., Singer, S., and Herrington, M. (2016) Global entrepreneurship monitor: 2015/16 global report. Global Entrepreneurship Research Association (GERA). <http://www.gemconsortium.org/report/49480>

Our trademarking activity



Trademarks serve to reinforce businesses' intellectual property (IP) strategies and can be considered an indicator of innovation performance.

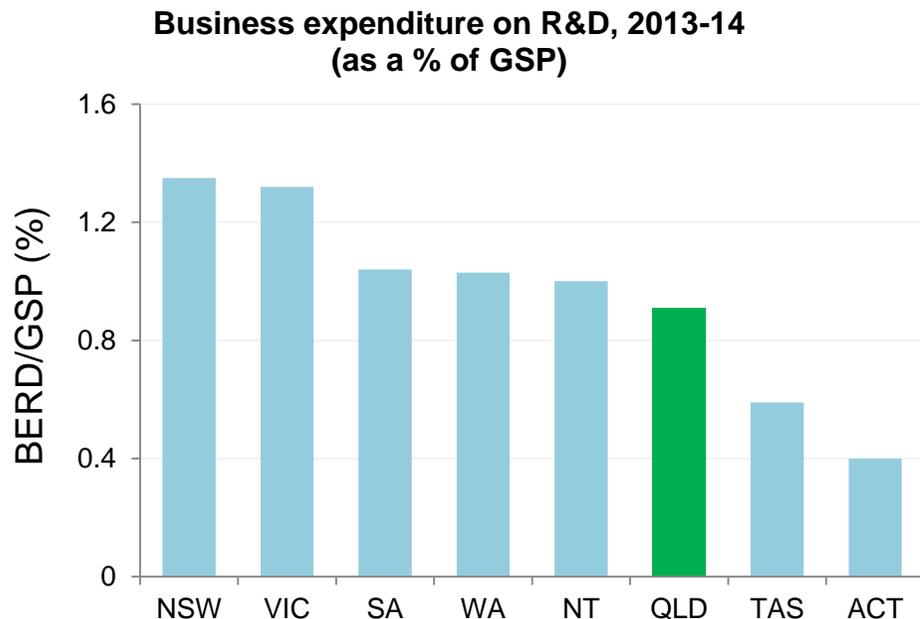
The average annual rate of trademark applications per 10,000 inhabitants from 2008 to 2014 shows most activity in capital cities, with Brisbane third in Australia after Sydney and Melbourne¹.

Among regions outside the mainland state capitals, Queensland (outside Brisbane) has the highest rate of trademark applications.

Source: Australian Bureau of Statistics (2011) *Population by Age and Sex, Regions of Australia*, 2011, cat. no. 3235.0, (data cube: Excel spreadsheet), viewed 8th May 2015, <http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/3235.02011>, Intellectual Property Government Open Data (2015), viewed 1st May 2015, <https://data.gov.au/dataset/intellectual-property-government-open-data>

Source: 1. Office of the Chief Economist (2015) *Australian Innovation System Report 2015* Department of Industry, Innovation and Science, Australian Government, November 2015, <http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/Australian-Innovation-System/Australian-Innovation-System-Report-2015.pdf>

Business investment in R&D



Source: Australian Bureau of Statistics Cat 8104.0, Research and Experimental Development, Businesses, Australia, 2013-14

Further to pages 37-38, Business Expenditure on Research and Development (BERD) as a per cent of gross state product for Queensland (0.91 per cent) ranked third lowest in Australia for 2013-14¹.

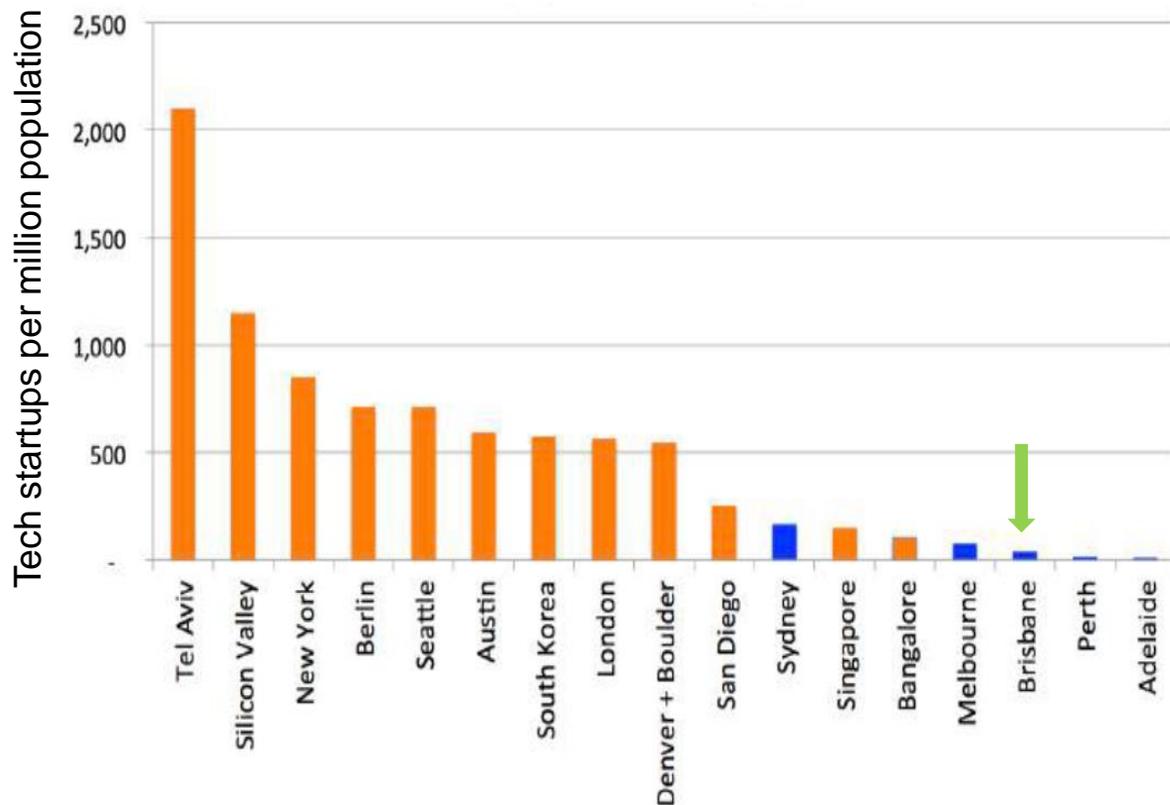
For the period 2006-07 to 2013-14, the Queensland average (1.10 per cent) compared with an average of 1.30 per cent for NSW, 1.34 per cent for Victoria, 1.10 per cent for South Australia and 1.56 per cent for Western Australia¹.

The private sector is responsible for more than 60 per cent of gross expenditure on R&D, but accounts for only 40 per cent of the research workforce. The public sector accounts for less than 40 per cent of gross expenditure on R&D but employs almost 60 per cent of the research workforce².

Most R&D expenditure tends to be conducted by larger more established firms, rather than new ones, and in capital intensive industries like mining and manufacturing³. For instance, two-thirds of BERD is carried out in large companies employing 200 employees or more (which also tend to be older firms that have had more time to grow)⁴.

Sources: 1. Australian Bureau of Statistics Cat 8104.0, Research and Experimental Development, Businesses, Australia, 2013-14 2. Miles, D.A. (2015) Growth through innovation and collaboration: a review of the Cooperative Research Centres Programme 25 March 2015 3. Australian Innovation System Report 2015 <http://www.industry.gov.au/Office-of-the-Chief-Economist/Publications/Documents/Australian-Innovation-System/Australian-Innovation-System-Report-2015.pdf> 4. Australian Bureau of Statistics (2013) Research and Experimental Development, Business Australia, 2011-12 cat no. 810.0, Table 2

Brisbane's tech startups



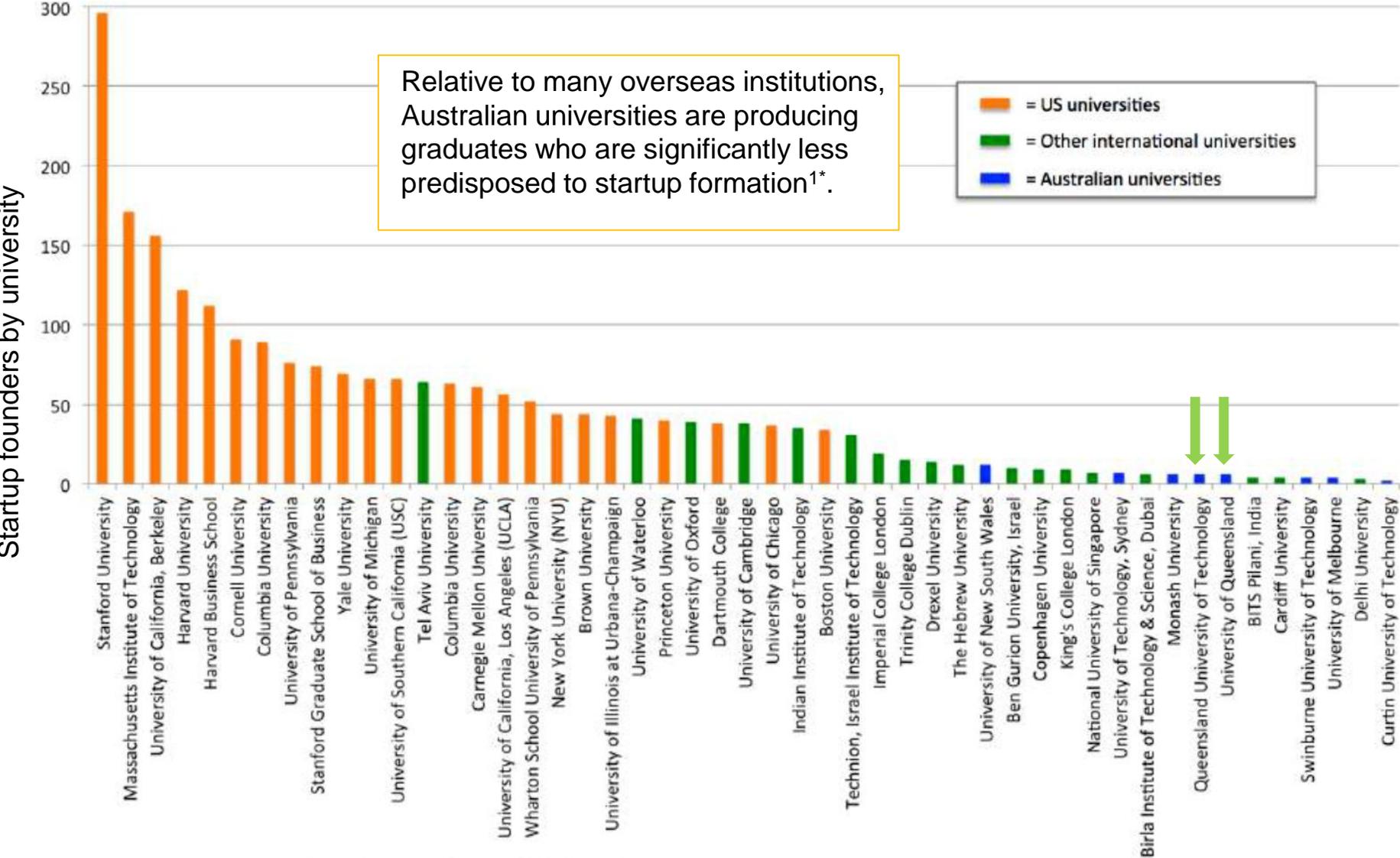
However, in a global context, Australia has a relatively low rate of tech startup formation¹.

The rate of startup formation in Queensland was estimated at about six startups per million people per year, with the national average around 20 to 30².

Comparatively, startup hotspots such as Boulder, San Jose, and San Francisco have an annual startup formation rate ranging from 100 to 250 startups per million people per year¹.

Sources 1. StartupAUS (2015) Crossroads 2015: An action plan to develop a vibrant tech startup ecosystem in Australia. 2015 p. 33 Figure 7. <http://startupaus.org/wp-content/uploads/2015/04/Crossroads-2015.pdf> 2. Cacioppe, J. (2015) Australia needs \$13 billion to fight off foreign tech Vikings. The Boundless Blog. 2015 <https://medium.com/the-boundless-blog/australia-needs-13-billion-to-fend-off-vikings-cd53866e83c6#.vdpxf56ck>

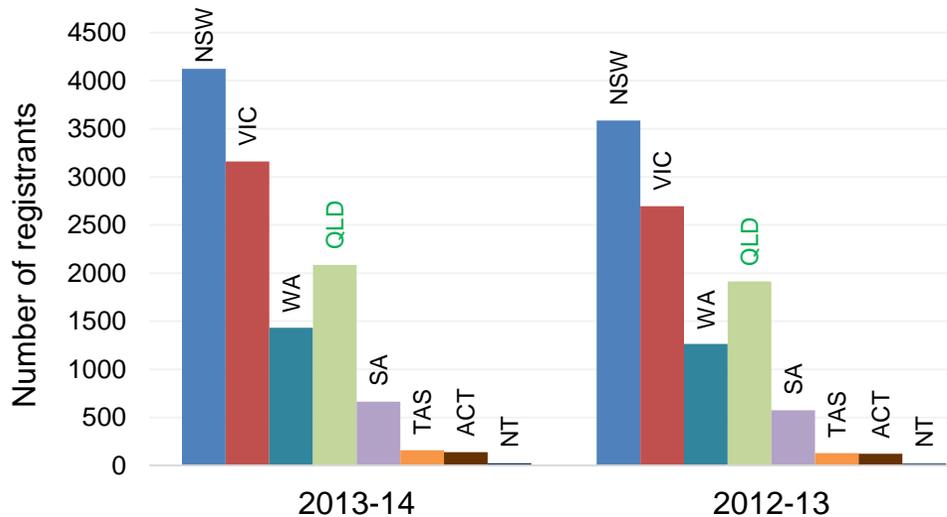
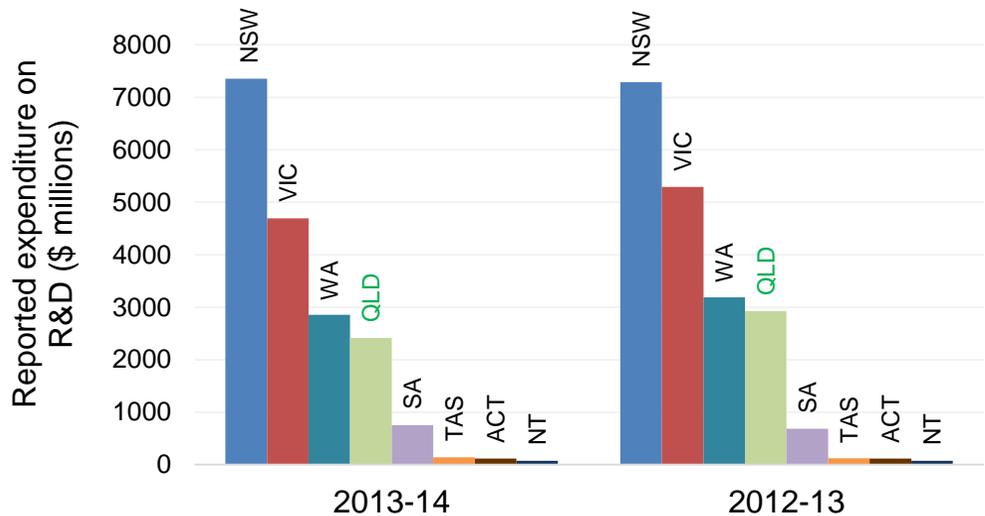
How do our university startups compare?



*The number of startup founders listed on CrunchBase as at 12 August 2013. CrunchBase is a free and voluntary database of technology companies, people and investors. <http://crunchbaseblog.golaun.ch/2013/08/12/entrepreneurs-and-universities/>

Source: 1. StartupAUS (2015) Crossroads 2015: An action plan to develop a vibrant tech startup ecosystem in Australia <http://startupaus.org/wp-content/uploads/2015/04/Crossroads-2015.pdf>, Figure 8. p 34 April 2015

The R&D Tax Incentive



The R&D Tax Incentive scheme is designed to encourage Australian companies to innovate. In 2014-15, the scheme helped 13,000 companies with \$2.4 billion in tax support for eligible R&D investment¹.

Queensland ranked fourth in reported expenditure on R&D and third in the participation rate (number of registrants) as at 30 June 2014 and at 30 June 2015 respectively^{2,3}.

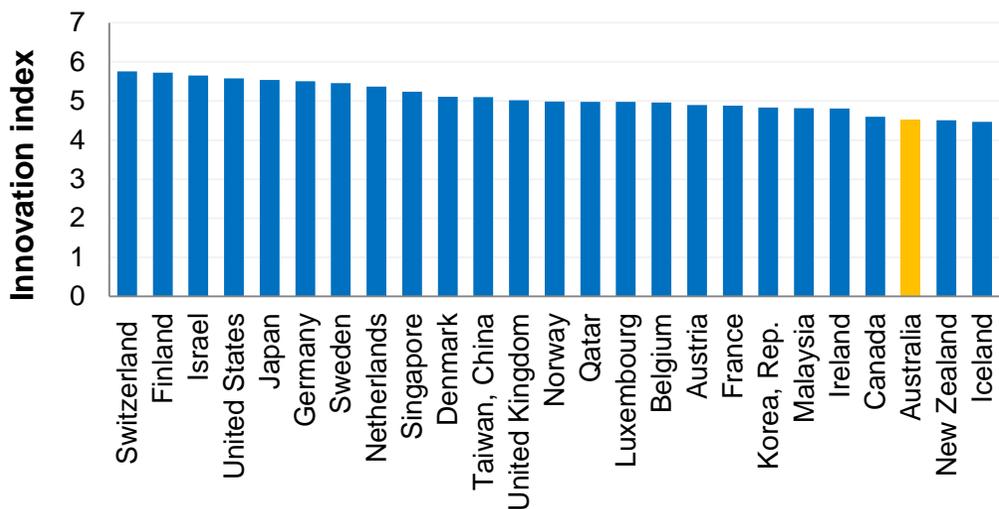
The data reflects a relatively higher proportion of SMEs, based in Queensland, registered for the entitlement scheme than for other jurisdictions. However, the number of Queensland registrants for 2013-14 (2086) represent only 0.5 per cent of the number of actively trading businesses (416,697 as at June 2014)⁴. Possible reasons for low participation include ineligibility due to corporate structure, are service-based companies which do not provide innovation services, or are not aware that it is an entitlement scheme.

R&D conducted in Queensland by firms headquartered in other parts of Australia may have contributed to a relatively higher registration of R&D by those jurisdictions.

Sources: 1. Pyne, C. (2015) Australia can be the startup and innovation nation under new Prime Minister Malcolm Turnbull. Minister for Industry, Innovation and Science, The Sydney Morning Herald, 22 October 2015 <http://www.smh.com.au/technology/innovation/australia-can-be-the-startup-and-innovation-nation-under-new-prime-minister-malcolm-turnbull-20151022-gkfrff.html> 2. Department of Industry (2014) Innovation Australia annual report 2013-14. Australian Government. <http://www.industry.gov.au/innovation/Innovation-Australia/Annual-reports/Pages/Innovation-Australia-Annual-Report-2013-14.aspx> 3. Department of Industry and Science (2015) Innovation Australia annual report 2014-15. Australian Government. <http://www.industry.gov.au/innovation/Innovation-Australia/Annual-reports/Pages/Innovation-Australia-Annual-Report-2014-15.aspx> 4. Australian Bureau of Statistics (2015) 8165.0 - Counts of Australian Businesses, including Entries and Exits, Jun 2010 to Jun 2014 <http://www.abs.gov.au/ausstats/abs@.nsf/mf/8165.0>

Australia's innovation performance

Innovation¹

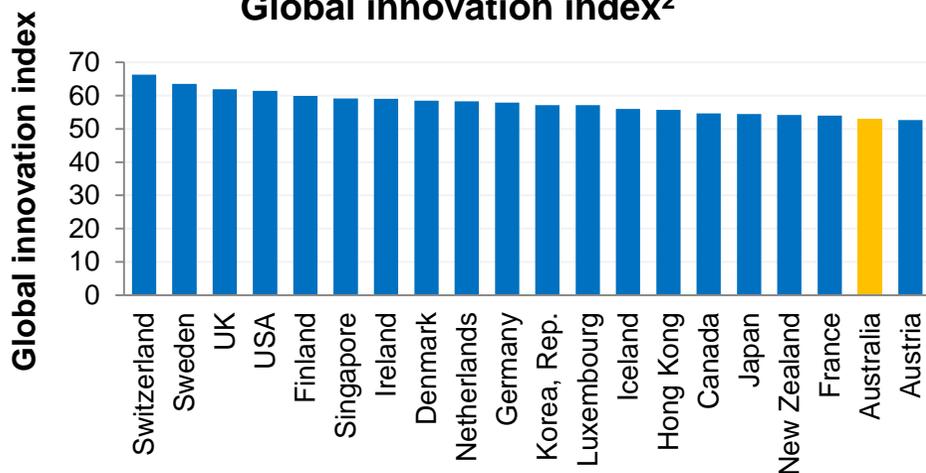


World Economic Forum (WEF)

Australia ranked 23rd out of 140 countries for innovation in 2015-16, up two places from last year (25th), but lower than our best ranking of 20th in 2009-10¹. In the 2016-17 data just published by WEF Australia has dropped to 26th.

“Australia...continues to lag behind most advanced economies in innovation... With global commodity prices set to remain low for the foreseeable future, along with the slowdown in China, the country must diversify further and move up the value chain.¹”

Global innovation index²



Cornell, INSEAD and World Intellectual Property Organisation (WIPO) Global Innovation Index 2016

For the overall Global Innovation Index, (the simple average of input and output scores), Australia ranked 19th out of 128 economies surveyed².

Sources: 1. World Economic Forum (2015) World Economic Forum Global Competitiveness Report 2015-16 *Klaus Schwab (Ed.) & Xavier Sala-i-Martin (Chief Advisor)*. World Economic Forum, Geneva. http://www3.weforum.org/docs/gcr/2015-2016/Global_Competitiveness_Report_2015-2016.pdf 2. WIPO, Cornell University, INSEAD (2016) The global innovation index 2016: winning with global innovation. Dutta, S., Lanvin, B., and Wunsch-Vincent, S. (Eds) http://www.wipo.int/edocs/pubdocs/en/wipo_pub_gii_2016.pdf

Innovations and startups: Observations and recommendations

- Queensland is gaining a reputation as a 'startup state' with rising startup formation and being attributed with the most even spread of innovative entrepreneurship in Australia. Strengthening startup formation outside South East Queensland is vital in nurturing our research and innovation capacity.

The \$6 million Regional Innovation Hubs initiative under Advance Queensland provides support for regional innovation by connecting local efforts, leveraging key regional strengths, and lifting the capability of innovative local firms.

- International evidence suggests that Australia is good at starting firms, but poor at growing them. Procurement contracts and knowledge transfer initiatives are important priorities to help small businesses grow.

This need is recognised by the Queensland Government's \$405 million Advance Queensland initiative, particularly through its programs designed for innovative government procurement and knowledge transfer.

- Less than 3 per cent of the \$19.7 billion claimed by companies as R&D under the R&D Tax Incentive entitlement scheme is spent in universities and research organisations where approximately 70 per cent of the nation's researchers are based.

Policies that promote collaboration between business and researchers should be a priority, recognising that the best researchers are commonly the most externally engaged and leading companies will want to work with the best researchers.

- To be innovative and competitive, many Queensland businesses are embracing new paradigms for competing in a global market - customisation, business model innovation, collaborative R&D, design-led thinking, digitisation, value-adding along the supply chain, adopting a systems approach, capability alignment, and accessing global value chains.

Policies, initiatives, and programs which support these new guiding principles are critical for skills development, future jobs, and the economic prosperity of Queensland.

- Critical to Queensland's innovation economy is a strong research base working collaboratively in close proximity with industry. There is a lack of a closely co-located innovative businesses around facilities undertaking research in Queensland, and possible sites have been proposed. Importantly, such effort must be strategic and start early, as long lead times are required to yield tangible outcomes.
- In addition to close physical co-location, critical to success is stewardship by experienced industry leaders, joint appointments from successful companies, student industry placement, startup formation, and an environment that encourages the flow of staff between the manufacturing industries and academic roles.
- The introduction of programs by both the Queensland Government and the Commonwealth Government has now led to a much more balanced approach for supporting the entire length of the commercialisation pathway. This new emphasis on innovation, entrepreneurship, and the 'D' component of 'R&D' will increase the chances of translation of our research and its commercialisation into goods and services.

Some highlights

TC Beirne Building - new startup and innovation precinct¹

A new startup and innovation precinct in Brisbane's Fortitude Valley will harness the power of collaboration and boost the state's burgeoning and vibrant startup sector. The precinct will be located in the TC Beirne building (a heritage-listed former department store built in 1902) and is planned to open in October 2016.

The Government is backing the project with a \$4 million Advance Queensland investment to ensure shared spaces are provided for Queensland's entrepreneurs to grow and flourish. The Precinct will scale up collaboration and bring together Queensland startups, incubators, investors, mentors and provide co-working spaces under the one roof, to help ideas, entrepreneurial spirit and business investment thrive.

RiverCity Labs will be among the precinct's first tenants and CSIRO's Data61 are also committed as foundation partner to share in this inspirational space.



Innovation Centre Sunshine Coast

The 'Silicon Coast' of South- East Queensland has quickly grown a reputation as one of the leading entrepreneurial regions of Australia, thanks in no small part to the role played by the Sunshine Coast's Innovation Centre. The Centre has played a pivotal role in boosting innovative entrepreneurship on the Sunshine Coast, having assisted with the launch of over 135 start-up companies, raising \$32 million in early stage capital and creating over 530 jobs in member companies.

The Innovation Centre currently assists 36 member companies with its purpose built 1500m² business incubator, dedicated Entrepreneur in Residence, a panel of 24 expert mentors, regular member events such as Pitch Competitions, Start-up Weekend, seed funding opportunities, and the chance to connect with like-minded entrepreneurs and university researchers.

The Innovation Centre's activities and members' successes have contributed to Sippy Downs being recognised as an 'Innovation Hotspot' now at the heart of a knowledge precinct, effectively linking entrepreneurs to the university's talent, programmes, immersive technologies and research facilities.



Advance Queensland Innovation and Investment Summit²

The Advance Queensland Innovation and Investment Summit captured the imagination of over 1400 attendees who walked through the doors of the Royal International Convention Centre during the inaugural event.

Inspired by 60 visionary speakers and more than 55 innovation showcase exhibitors, the venue was buzzing with ideas and connections as the conversations flowed between startups, entrepreneurs, businesses, researchers and investors.

The livestream of the event reached a further 3000 Queenslanders, as they tuned in to join the event from all over the state, sparking a flow of social media commentary as the summit trended on Twitter with over 2300 tweets and 80,000 views within the official summit app.

Some highlights

Research Directions Pty Ltd¹

Research Directions is a Brisbane-based SME specialising in the advanced manufacture of organic compounds and chemistry consulting. Recently, the company has embraced innovative flow chemistry to produce high-value chemicals for international markets. Australia does not have significant manufacturing capability for organic compounds.¹



CEO, Dr Stephanie Smith, said that the recent advent of flow chemistry techniques will enable the company to take on international competitors which have lower wage costs than in Australia. Additionally, the new processes enable the large scale manufacture and synthesis of chemicals in much smaller production facilities than required by traditional manufacturing.

Staff employed at Research Directions are highly qualified, with 80 per cent possessing a PhD in organic chemistry. The company is collaborating with several other Australian SMEs and is a member of the Innovative Manufacturing CRC.

DoseMe²

An app that supports clinicians in enhancing patient outcomes through precision dosing. Pairing complex algorithms with a simple app-based user interface allows clinicians to access the DoseMe platform anytime, anywhere. It uses patient data and laboratory results to estimate a person's metabolism and their ability to absorb, process and clear a drug from their system - helping clinicians to dose more accurately by calculating the most effective dose to reach the desired outcome.

The system has the potential to deliver significant cost savings and efficiencies, and most importantly, has the capacity to save lives all over the world.

In August 2016, the privately held digital medical solutions provider, founded by Dr Robert McLeay, with CEO Charles Cornish, raised \$2.6 million Series A financing, valuing the company at \$20 million.



DoseMe is easy-to-use software that allows clinicians to dose a patient based upon that patient's individual ability to absorb, process, and clear a drug.

Cook Medical Australia³

Brisbane-based medical manufacturer Cook Medical Australia is a leader in R&D of endovascular stents and IVF technologies, and in 2014, manufactured more than 10,000 stent grafts, used for the treatment of aortic aneurysms, along with more than 3000 custom-made medical devices and 750,000 needles to assist in reproductive health treatment. All up, 92 per cent of its locally manufactured products were exported last year, totalling \$119.3 million.

Managing director Barry Thomas says the company is committed to supporting and promoting local manufacturing, particularly because its aortic stent grafts were developed and commercialised from Australia.

"We are always looking in the pipeline for new ideas," he says. "We have been working with and will continue to work with physicians, innovators research centres, universities and anyone else who is willing to back themselves with an idea that fits within our company mould. If it doesn't, we will try and help find someone that can."

Some highlights

Redback Technologies¹

A Brisbane-based startup that provides advanced hybrid technology that enables the ability to store, monitor, and manage a home's solar energy that maximises renewable energy consumption at home. All in a compact, elegantly design unit mounted either inside or outside the home.

The Redback Solar System offers the functionality to store energy, which can be used for personal use or be sold back to the grid. Founder and Managing Director of Redback Technologies, Philip Livingston, stated that the growth in clean energy has created a promising new market that is driving employment opportunities for those in STEM sectors.

Redback Technologies recently unveiled their new offices at The University of Queensland campus in Long Pocket. The new facility will be used for research and development of new software and hardware that enables homeowners to store, monitor and manage solar energy more efficiently.



Minister for Main Roads, Road Safety and Ports and Minister for Energy, Biofuels and Water Supply, Mark Bailey (left) with Founder and Managing Director of Redback Technologies, Philip Livingston (Right)

RedEye Apps²

RedEye Apps was founded in Brisbane by Wayne Gerard in 2011. RedEye is the first fully cloud-based and purpose-built engineering management solution and platform for asset owners and their service providers globally. It is about managing the versions of engineering drawings, keeping them in a central place on the cloud and making them easy to find and share. This saves up to six per cent of project costs just by making sure people are working off the right version of a drawing.

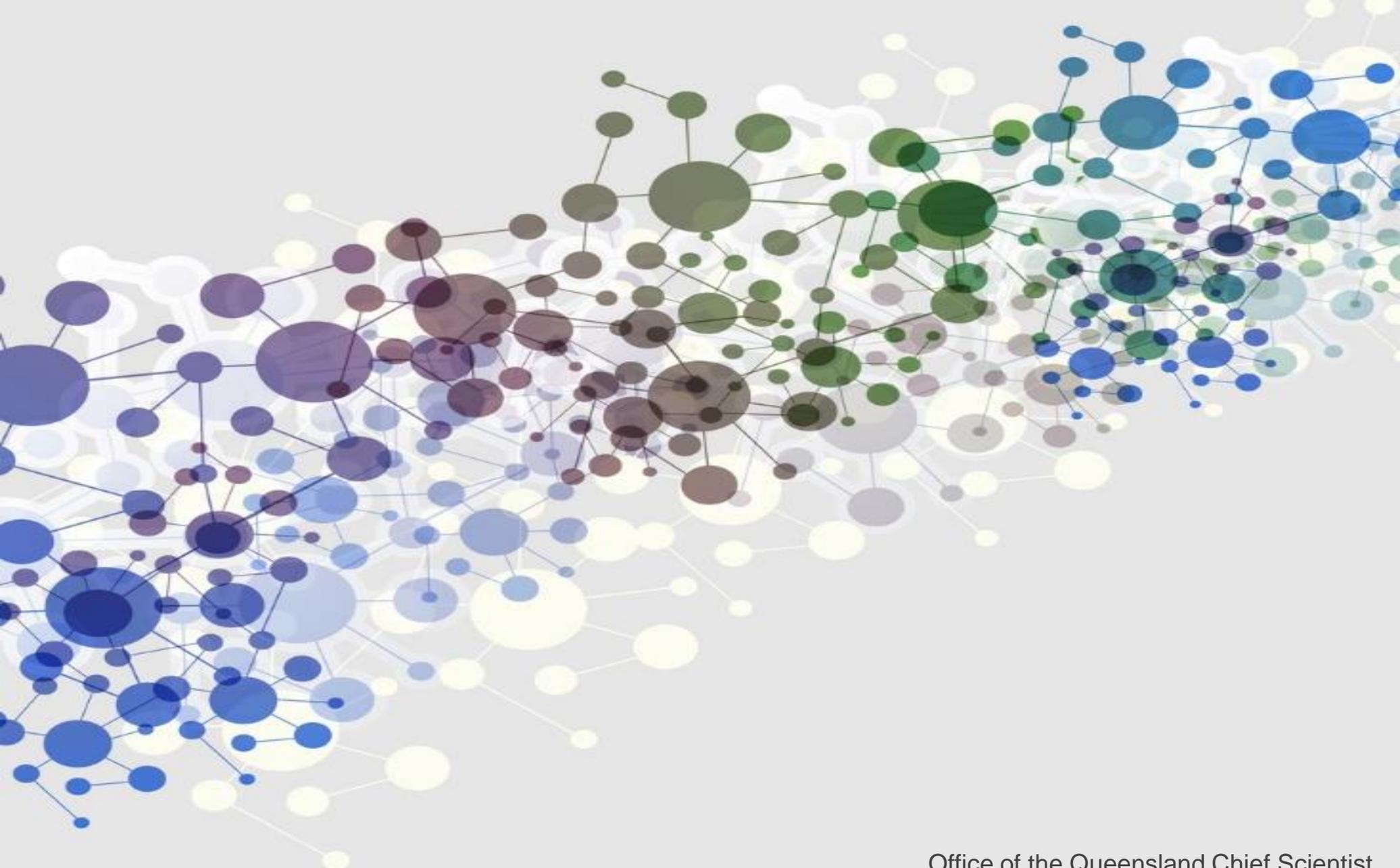
RedEye Apps was a finalist in the 2013 Lord Mayor's Business Awards. Mr Gerard says the Brisbane business landscape is ripe for innovators with an entrepreneurial spirit. Recently RedEye recently welcomed the awarding of a \$250,000 business grant under Advance Queensland's Ignite Ideas Fund. Prior to RedEye, Wayne also co-founded Waterline Projects, a multi-discipline engineering services company focussed on building long-term client relationships in the Australian Mining and Energy sectors.

Wayne has also been a member of the Entrepreneur's Organisation (EO) since 2009, serving as a board member in the Brisbane Chapter 2009-2011. EO is the world's leading peer to peer learning environment for entrepreneurs. Wayne is Chair of the Chamber of Commerce and Industry Queensland's Innovation Committee.

Euclidean³

Euclidean is a forward-thinking, advanced technology company based in Brisbane, best known for its UD (unlimited detail) 3D visualisation technology, which has been covered by some of the biggest publications in the world, including New Scientist, Popular Scientist, Game Informer and Rolling Stone magazines. The revolutionary nature of UD is a complete rethinking of what was considered possible and is a fundamental philosophy of the company.

In 2010, Euclidean received one of the largest government grants to commercialise UD with the first offering being its geospatial software offering, Geoverse. By continually developing technologies that redefine the status quo, Euclidean has proudly positioned itself as a pioneer in the field of 3D visualisation - setting new industry benchmarks, and enabling customers to use data in completely new and exciting ways. Euclidean's unparalleled, ground-breaking technology has opened a whole world of new opportunities, inspiring its customers to create new products, new levels of efficiency, new insights into data, new ways of presenting ideas, and countless other future possibilities, not yet able to be imagined. Euclidean is working closely with the Queensland Museum to provide virtual tours of sites such as the Lark Quarry dinosaur trackway at Winton.



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