Pre-Budget Submission to the 2018-19 Federal Budget

Executive Summary

The Australian Academy of Science comprises more than 550 of the nation's most distinguished scientists. It has active groups of Fellows throughout Australia who are extensively networked nationally and internationally.

In an increasingly uncertain and challenging world, we Australians will need to make every effort to build an economy and a workforce able to support the future we choose: a future that will be heavily constrained by national and global factors.

Science, technology, engineering and mathematics (STEM) underpins almost every aspect of societal advancement—from solving major global problems to spawning new businesses, keeping existing ones competitive and creating jobs. It will be a fundamental foundation on which our chosen future will be built.

For Australian science and research to be able to effectively address our own challenges as well as being a valued contributor to global solutions, the level of investment must at least be on parity with other developed countries. This is not the case. Australian government investment in R&D as a proportion of GDP has fallen from a high of 0.67 percent in 2011-12 to 0.48 forecast in 2019-20[1].

In order to guarantee our place as an advanced industrialised economy into the future, this needs to change.

Our key recommendations to the Commonwealth Government for the 2020-21 budget are:

- Develop a long term, stable, forward looking plan for science, economic prosperity and future jobs
- Continue performing NISA national STEM Education programs, including those in partnership with the Australian Academy of Science
- Set a national target for expenditure across the economy as a proportion of GDP
- Incentivise business investment in R&D by implementing a collaboration premium for the non-refundable offset component of the R&D Tax Incentive as recommended by the Fraser, Ferris and Finkel review
- Implement an international science strategy that recognises science as a strategic soft power asset; supports Australian foreign policy objectives; maintains our participation in key international science bodies; support bids to attract major international scientific

[1] Department of Industry, Innovation and Science (2019), '2019-20 Science, Research and Innovation Budget Tables', https://www.industry.gov.au/data-and-publications/science-research-and-innovation-sri-budget-tables

conferences to Australia; to forge bilateral and multilateral scientific relationships; support emerging research and researchers; and expand our science diplomatic capabilities.
- Support the implementation of the Women in STEM Decadal plan in partnership with the Australian science sector

Preparing for the next natural disaster

The scientific evidence base shows that as the world warms due to human induced climate change, we experience an increase in the frequency and severity of extreme weather events.

As a nation, we must deal with extreme weather events more effectively than we currently do. As such events become more frequent and severe, we must adapt Australia and Australians accordingly, as well as strengthen mitigation efforts.

Bushfires, along with other weather and climate challenges, pose complex and wide-ranging problems. Population growth, climate change, temperature extremes, droughts, storms, wind and floods are intersecting in ways that are difficult to untangle and address.

The good news is that there is already abundant evidence available to help us understand the environment we live in and to design and build the future we want for Australia. There has never been a more important time to draw on that scientific evidence base to help guide Australia's short- and long-term responses to the devastating bushfires ravaging our nation and that are causing uncertainty about our future.

The Academy's Fellows are contributing and will continue to contribute their scientific expertise to government and other decision makers in the interest of advancing our nation.

The Academy is resolute that the response to the bushfires must extend beyond the immediate and essential need to rebuild and recover.

Everything, including urban planning; building standards; habitat restoration; biodiversity and species preservation; and land, water and wildlife management will need careful and measured consideration.

We must further improve our ability to forecast changing environmental threats and continually improve climate modelling predictions. We must improve our understanding of fire behaviour and other adverse weather events, and we must continually develop new technologies, practices and behaviours to assist our nation to respond and adapt to, manage, and mitigate against such extreme events.

All the while, Australia must take stronger action as its part of the worldwide commitment to limit global warming to 1.5° C above the long-term average to reduce the worst impacts of climate change.

To have the best chance of succeeding, we must draw on all the available evidence and knowledge, including working with Aboriginal and Torres Strait Islander peoples and undertaking further research where it will have the most benefit.

Science in a changing world

The Prime Minister has observed we are "living in a world in transition". The future for Australia presents many uncertainties, but also opportunities.

Australia has enjoyed three decades of uninterrupted economic growth, liveable cities, natural beauty and strong social cohesion.[2] But the continuation of this success cannot be assumed. We face, together, an uncertain geopolitical and economic environment, a natural world under pressure and challenging economic performance domestically. Reports, including both the CSIRO National Outlook, and Innovation and Science Australia's *Australia 2030: Prosperity through innovation* have identified as national priorities the need to improve our performance in STEM education, and reversing the decline in business investment in research and development.

Science and technology are changing our industries, and the way we live, work and interact with each other – a process often called the fourth industrial revolution or Industry 4.0. Technology is changing the skills that will be needed in the workforce of tomorrow. As noted by the CSIRO National Outlook, "The World Economic Forum's latest jobs report stresses that if adaptation strategies are in place, embracing technology can have a net positive outlook for jobs, with job creation outweighing displacement."[3]

Science is the answer to the challenges of an uncertain world

Science and the capacity to make judgements and policies informed by scientific evidence are of paramount importance. Indeed, comparable countries have already developed long-term strategic plans that build on national capacity in science, technology, engineering and mathematics (STEM) to deliver high-value industries and jobs for the future.

These plans are accompanied by resources to ensure that the personnel, the infrastructure, and the partnerships are in place to drive innovation and build prosperity. They include concerted approaches to extend capacity and basic understanding of science across the population, and to overcome barriers to participation in STEM resulting from outdated practices and cultures.

To compete internationally and ensure continued prosperity, health and wellbeing, Australia must plan for and invest in STEM on par with the best in the world.

Without stable support for research infrastructure and for basic and applied science, Australia risks losing knowledge and expertise and damaging the training pipeline of high-skilled STEM professionals. Lack of stable support for science also risks creating an 'innovation gap', where the pipeline of people and ideas falls short of the skills, the capability, and the collaboration needed to feed the development of new products and services for domestic and international markets.

A well-planned and well-resourced STEM education and research capability is necessary to drive innovation and growth into the future.

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[2]

[3] CSIRO (2019), 'Australian National Outlook 2019', p. 9, accessed from https://www.csiro.au/en/Showcase/ANO.

Making Australia a world leader in STEM education

The Australian Academy of Science recognises high quality education as a cornerstone of Australia's democratic society and a key driver of national prosperity.

A well-educated, literate and numerate populace is essential for a society to make rational and informed decisions about the future, while making a valuable contribution to national prosperity and the search for effective solutions to global challenges. The rich diversity of Australia's population has the potential to be a powerful driver for innovation.

Science, Technologies, Engineering and Mathematics, the STEM learning areas, are oriented toward knowledge generation and problem solving. Underpinned by strong literacy and numeracy learning and development, these abilities are integral to the development of the widely applicable critical thinking skills which are necessary for navigating complex and dynamic environments.

Commonwealth and State governments have taken steps to reverse the decades-long downward drift in enrolments and performance in STEM subjects in schools. In December 2015, Australia's Education Ministers endorsed the National STEM School Education Strategy 2016-2026.[4] This strategy has two goals:

a) To ensure that all students finish school with strong foundational knowledge in STEM and related skills, and

b) students are inspired to take on more challenging STEM subjects.

The strategy needs to be continued to be implemented comprehensively, at scale and in all regions of Australia: metropolitan, regional and remote.

Engagement with critical influencers: Investing in teachers is an investment in our future

The greatest strength of Education at the Australian Academy of Science is the demonstrated delivery of effective support to in-service and preservice teachers, which is essential to changing practice to improve student engagement and learning outcomes.

Teachers play a major role in determining students' attitudes, beliefs and confidence in STEM fields. Both initial teacher education and continued professional learning support throughout a teacher's career impact how teachers work with and influence their students.

The challenges and opportunities of a rapidly changing world affect today's students and their teachers. As information, ideas and technology rapidly evolve, it is critical to support teachers to keep their capacity and development current in meaningful ways. To do so requires a shift in the way we engage with and support teachers, a shift the Academy is ready to respond to and deliver.

The Australian Academy of Science has a proven track-record, unparalleled experience and international reputation in developing and delivering effective, research-based education resources for students and quality teacher professional learning across science and mathematics from Foundation to Year 10.

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[4] Education Council (2015), 'National STEM School Education Strategy', accessed at www.educationcouncil.edu.au/site/DefaultSite/filesystem/documents/National%20STEM%20School%20Education%20Strategy.pdf

Further strengths are that the Academy's programs embody Australian content and contexts, are aligned to the Australian Curriculum, and are recognised as quality resources developed by a trusted source. The Academy is adept at designing for and delivering to the diversity of schools and teachers across the nation, spanning remote, regional and rural locations as well as metropolitan settings.

The Academy's approaches align with the priorities of the National STEM School Education Strategy 2016 to 2026 (Education Council 2015) and the goals of the Alice Springs (Mparntwe) Education declaration (Education Council 2019) building on and leveraging these national objectives and plans.

Given the Australian Academy of Science's national reach, strong track record in developing and delivering proven programs, and substantial depth and breadth of experience and resources to draw on, the Academy is ideally positioned to continue its successful partnership with the Commonwealth.

This should involve continuing the high performing NISA national STEM Education programs, including those in partnership with the Australian Academy of Science

Supporting the economy through science and research

Direct Australian Government investment in research (grants and program allocations; excluding tax concessions) has declined as a percentage of Gross Domestic Product (GDP) from 0.41 percent in 1992-93 ($1.56B) to 0.19 percent in 2016-17 ($3.3B). At the same time business investment increased from 0.64 percent of GDP to a peak of 1.37 percent in 2008-09. By 2016-17 this has fallen to 0.9 percent[5]

This trend stands in contrast to sustained increases in countries such as the US, China and Korea[6]. It also reflects a shift away from support for 'public good' research – the patient capital that supports research in the pursuit of knowledge or research that will *create an environment for the inspired risk-taking that is essential to technological discovery*[7]. In other words, there is a transfer of emphasis towards using intellectual capital and away from generating it.

Not only is there a downwards drift in the funds available '*…successive governments' practice of funding long-term [research] investments on short-term funding cycles'*[8] compounds the issues facing both researchers and industry investors. Public funding for science and research is both decreasing as a proportion of GDP and is dominated by short funding cycles.

This makes research careers in STEM less attractive at the very time we need more and different skills and perspectives. The implications for the pipeline are obvious: early-and mid-career researchers leave universities and publicly funded research institutes for more secure careers, with only 27% of Australia's 151,000 employed PhD graduates remaining in academic and other research professional roles over time[9]. This is further complicated by the weight given to 'track-record' in the assessment of grant applications.

Research in Australia is not funded fully. Indirect costs of maintaining and sustaining research program are not covered by most research grant programs, meaning that research organisations have to meet these costs from other revenue streams[10].

The Academy acknowledges that there are no simple solutions. In the absence of a comprehensive national strategy for STEM, the profile of STEM research is heavily influenced by funding models rather than a strategic positioning.

For Australian research to be able to play an effective role addressing our own challenges as well as being a valued contributor to global solutions, the level of investment should be consistent with that in other developed countries.

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[5] Australian Bureau of Statistics (2017), "Research and Experimental Development, Businesses, Australia, 2017-18"; and Australian Bureau of Statistics (2018), "Research and Experimental Development, Government and Private Non-Profit Organisations, Australia, 2016-17".

[6] OECD Main Science and Technology Indicators. www.oecd.org/sti/msti.htm

[7] A moment of truth for America: An open letter to Congress from the executives of some of America's leading technology companies. (1995). Accessed at https://homes.cs.washington.edu/~lazowska/cra/ceo.letter.html

[8] Research Infrastructure Review, 2015. p.viii.

[9] ABS Census Data. Occupation and highest educational attainment, 2016

[10] Allen Consulting Group (2008), Recognising the full cost of university research.

We have long advocated for policy change to ensure that Australia grows its proportion of R&D investment from 1.88 percent to 3 percent across the economy. In the OECD, 23 countries have set targets, including many European nations, to Canada, Mexico, New Zealand, Turkey and the USA[11]

Australian business, compared to or competitors, do not invest in research and development. It has long been noted that we underperform in collaboration between firms, between firms and universities, and firms and research agencies. Increasing the variety of collaborative business R&D funding will remove barriers to innovation and incentivise further cooperation and collaboration. Subsidies and grants for business R&D produce spill-over benefits in the form of increased business R&D intensity and spending. Incentivising collaborative activity creates productive linkages and innovation outputs.

This was a key message of the Ferris, Finkel, Fraser Review of the R&D Tax Incentive in 2016 and the Academy supports the recommendation of that Review for a collaboration premium for the non-refundable offset component of the R&D Tax Incentive.

The Academy stands ready to work with Government to identify the means by which Australia can transform investment in research and development, the time-frame for its achievement and the ways it could be used to provide incentives to researchers and business to co-operate better than at any time in our history.

[11] Borowiecki and Paunov (2018), 'How is research policy across the OECD organized?' OECD

Strengthen and maintain a commitment to a global community of scholars and scientists

Science is a global enterprise and many of the existential challenges of our time, such as the health and sustainability of the planet, are too complex for any one country to undertake alone. Australian researchers must be globally connected to draw from the best in the world, while actively participating in the search for solutions to global problems where we have capability.

There are very few nations that do not contribute in some way to the global effort in science. Australia's contribution is reasonable given our population size: some 3 percent of global research output. In terms of highly cited work, Australia fares even better, ranking 8th of 36 OECD+ countries in the top 1% of highly- cited publications per million population[12]

A key to further advancement of Australian science is to build global connectivity – links to the other 97 percent. This requires strategic and sustained investment. It provides Australia with the opportunity to contribute to the search for solutions to the large and complex problems that require multilateral effort. But it is not only external influence; the return is substantial: a valued contributor with early insights into new developments can benefit the Australian community.

Governments around the world have recognised the benefits of international research collaboration. It benefits individuals, institutions and nations–and people's lives.

Australia's national interest is well served when scientific collaborations open doors and broker dialogue with other nations, especially where geopolitical issues might slow positive cooperation. Science diplomacy is powerful and must be formally recognised as a soft power asset.

The Academy can help the Commonwealth further refine its international engagement strategy for science, technology and innovation. This will need to consider support to maintain our participation in key international science bodies, support bids to attract major international scientific conference to Australia (with the resulting economic benefit), forge bilateral and multilateral scientific relationships, support emerging research and researchers, expand our science diplomatic capabilities and support Australian foreign policy objectives through science diplomacy.

[12] OECD (2016) Main Science and Technology Indicators, 2016-1, accessed at https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB 332; and Thomson Reuters (2016) InCites, accessed at https://incites.thomsonreuters.com/

Australian Science must draw from all the talent available to the nation

Australia is characterised as a culturally diverse community. The demographic profile of STEM in Australia is not: there are fewer women in key STEM subjects (physics, chemistry, advanced mathematics) in senior school[13], for example, and regional and remote students too often do not have access to the well-supported teachers and facilities that are enjoyed in the metropolitan areas[14]. Even in metropolitan areas there are differences in participation between suburbs[15]. The effect is a STEM demographic profile that is the consequence of barriers to access rather than interest or capacity.

It is inexcusable for Australia to continue to accept that it is tolerable to exclude large sections of the community from full participation in STEM because of what they are, who they are or where they are.

The barriers to participation are well known, and improvement is being made slowly. If Australia is to draw from all the talent available, however, barriers to participation, such as those related to diversity of background, gender, indigenous, disability or geography, must be eliminated.

The Academy, with the support of the Commonwealth Department of Industry, Innovation and Science, produced the Women in STEM Decadal Plan in 2019 and continued support is required to work with stakeholders to fully implement the plan.

[13] Justman, M. & Mendez, S. (2016). Gendered selection of STEM subjects for matriculation. *Melbourne Institute Working Paper No. 10/16.*

[14]. Australian Council for Educational Research (2018), 'Challenges in STEM learning in Australian schools: Literature and policy review', accessed at. https://research.acer.edu.au/policy_analysis_misc/28/

[15] Public Education Foundation (2018), 'What price the gap? Education and inequality in Australia', accessed at https://publiceducationfoundation.org.au/wp-content/uploads/2018/04/Issues-Paper_What-Price-The-Gap.pdf