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Business Council of Australia

Unlocking the innovation potential of Australian companies

The role of large Australian companies in achieving greater commercial outputs from science and technology

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This report was authored by Katherine Wynn, Mingji Liu, James Deverell, Jasmine Cohen and Raghav Sharma with contributions from business and research leaders.

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Contents

Stakeholders consulted

We thank the following stakeholders who provided their valuable insights during the development of this report:

Kim Krogh Andersen
Group Executive, Product and Technology, Telstra

Michael Bedwell
Head of Government & Education, National Australia Bank

Karen Dobson
President, Dow Australia and New Zealand

Michael Edwards
General Manager, Boeing Research & Technology Australia

Sally Fielke
General Manager Corporate Affairs, Coles Group

Adam Fitzgibbons
Head of Public Affairs, Coles Group

Naomi Flutter
Executive General Manager, Corporate Affairs, Wesfarmers

Shaun Gregory
Executive Vice President Sustainability and Chief Technology Officer, Woodside Energy

Ian Hansen
Chief Executive Officer, Wesfarmers Chemicals, Energy & Fertilisers

Brad Hordern
Executive General Manager, Supply Chain and IT, DuluxGroup

Patrick Houlihan
Chairman and Chief Executive Officer, DuluxGroup

Brendan Howard
General Manager, Technical Capability, Rio Tinto

Dig Howitt
Chief Executive Officer and President, Cochlear

Ian Jacobs
Vice-Chancellor, University of New South Wales

Jeanne Johns
Managing Director and Chief Executive Officer, Incitec Pivot

Catherine Livingstone
Chair, Commonwealth Bank of Australia

Alex Lynch
Head of Public Policy, Google Australia

Sam Maresh
Country Leader, GE Australia

Larry Marshall
Chief Executive, CSIRO

David Masters
Director of Global Public Policy, Atlassian

Hannah McCaughey
Group Executive, Transformation and Technology, APA Group

Steven Miller
Chief Operating Officer, Microsoft Australia

Brooke O'Rourke
Head of Government Affairs and Sustainability, Cochlear

Andrew Penn
Chief Executive Officer, Telstra

Tania Rhodes-Taylor
Vice Principal, External Relations, University of Sydney

Scott Riddle
Partnerships Manager, Google Australia

Rob Rounsley
Chief Technology Officer, Incitec Pivot

James Wiltshire
R&D Technology Leader, Dow Australia & New Zealand

Steven Worrall
Managing Director, Microsoft Australia

Foreword

Australia has a proud history of innovation, from the stump-jump plough and the mechanical sheep-shearing machine right back to the boomerang and fire-stick farming. Over the centuries we've used science and technology to transform our resources and agricultural sectors into world-leading export industries and we've led in the development and adoption of world-class digital and medical technologies.

We've enjoyed nearly three decades of uninterrupted growth, but that had already slowed in recent years, well before our economy was brought to a grinding halt by the COVID-19 pandemic. When we start to see a light at the end of what has been a very long and dark tunnel, we will have an opportunity to decide how we will apply that Aussie ingenuity again to build back better.

COVID has accelerated our national digital transformation, but we shouldn't be dazzled by digital – it's an important part of science, but it is only one part. To truly reimagine and reinvent our industries, to access new markets, and to build in resilience at the foundations, we must embrace the full power of every part of science and technology. Just as diverse teams deliver superior performance, diversity of science and technology delivers whole new industries, because innovation happens at the intersections of people and domains – collaboration is the key to innovation.

This report examines the role of collaboration, both industry to research and business to business, to help us achieve that. It brings together CSIRO's recent analysis, including the *COVID-19: Recovery and Resilience* report, with insights from industry leaders to outline how Australian businesses can play a big role in shaping our future.

Inventions from science, delivered as innovations through technology, will be crucial to Australia's future prosperity, but industry partnerships are the way those inventions will become innovations that move markets and have impact. In short, we need to kick-start the commercialisation engine that will speed us to a technology-led recovery.

There are some major barriers to commercialisation which we need to overcome, but again, business can play a big role in this. Collaborating with research and investing in R&D, embracing a culture of innovation, developing an innovation strategy, and investing in the skills and talent that will take it forward are all practical steps in the right direction.

By accessing our world-class research sector and investing in this way, we will see more Australian companies gain a competitive advantage from science, and more great Australian science converted into commercial benefit.

As Australia's national science agency, CSIRO is the bridge between lab bench and business, helping scientists from all Australian institutions to create companies and helping all Australian companies to benefit from science. Over our 100-year history, we have partnered with industry to invent many products used by Australians everyday – like Aerogard, long-wear contact lenses, and 'Softly' woollens detergent. All of these needed an industry partner to get them off the ground.

We continue to partner with industry in a range of different ways from co-investment and co-development of solutions, or engineering promising ideas into real prototypes that customers can test, through to helping to overcome IP and licensing challenges. We help to found and nurture deep tech companies through our CSIRO Innovation Fund, managed by Main Sequence, which has just raised an additional $250 million to address the valley of death between science and engineering discoveries and commercialisation. And we host an incubator for start-ups and small-to-medium businesses at our Lindfield Collaboration Hub in New South Wales and our Lab 22 advanced manufacturing facility in Clayton, Victoria, where they can access our infrastructure, expertise, and networks to develop and grow.

Aussie ingenuity is alive and well, but innovation is a team sport. If we are to realise a bold, technology-led recovery, we will need business and research playing together to win.

Together, we will build back better.

Larry Marshall
Chief Executive, CSIRO

From riding on the sheep's back to building a world beating resources sector, Australia has a long history of economic transformation.

By harnessing new technology and innovating, Australian businesses have helped ensure that our nation's luck has translated into a strong economy, better living standards and greater opportunities.

From agriculture, to mining, to services, Australia's private sector is one of the most advanced in the world.

As we emerge from the pandemic, Australia finds itself in the crosshairs of several major global shifts including the rise of Asia, technological and digital advances and the adoption of green energy sources.

In a world more competitive than ever, rekindling the spirit of ingenuity and invention has never been more important to secure our long-term economic future.

We're well placed to meet these challenges. We have world class universities and research institutions such as CSIRO, and some of the most innovative businesses on earth with balance sheets to invest and a proven track record.

But at times we have been a nation that gives away some of our best ideas to be scaled up and commercialised overseas.

Missed opportunities such as modern solar cells, the black box and the pacemaker.

We can't repeat the mistakes of the past and allow good opportunities to slip through our fingers.

The pandemic has radically shifted our economic and strategic position, digitisation continues to accelerate and the world is in a race to decarbonise.

Nations that act now to seize the first mover advantage on new technologies will lock in their gains and those that don't will simply fall behind.

Right now, we need leadership from businesses and government that inspires and grasps opportunities to take the country forward.

Leadership that guides us along the steps we need to take to secure our economic future and in doing so make ourselves more secure in a less secure world.

If we act now, we can lock in another 30 years of growth and prosperity.

It means we'll have to take a team Australia approach to building a more innovative, more diverse and more advanced economy.

That challenge starts by building on our existing strengths, learning from our best innovators, coordinating for impact and leveraging our natural endowments.

Our proximity to the growth centres of Asia, our skilled people and know-how mean we can be the best at producing goods and services that the rest of the world needs as part of global supply chains.

To remain competitive and avoid missing out on making the most of our world beating ideas, Australia needs to build the capacity for continuous research translation and commercialisation fund.

Working with CSIRO we have delivered a clear framework to give Australian businesses of all sizes the tools they need to do even more.

Unlocking the innovation potential of Australian companies gives businesses of all sizes a chance to start this work now, get ahead and set themselves and the country up for the future.

Australia is the lucky country, let's work together to keep it that way.

Jennifer Westacott AO
Chief Executive Officer, Business Council of Australia

Executive summary

COVID-19 was an unprecedented shock to the Australia economy, even in the years leading up to the pandemic, Australia's economy appeared to be losing its momentum and was facing long-term challenges:

Low productivity, low business investment, and stagnation in several industries

Low economic diversity in its industrial base and exports, and low diversity in its trade and investment partners

Disruption risks from emerging technologies

Australia has an opportunity to address these challenges and improve its competitiveness. If we don't, we risk being left behind.

Modelling from CSIRO's Australian National Outlook 2019 assesses two potential future scenarios for Australia. Transformational change and adoption of technology is critical to drive productivity and economic growth in Australia.

GDP per capita in 2060 would be **33–36% higher** in an optimistic scenario, compared with a pessimistic one, with over half the difference coming from **technology-fuelled increases in productivity.**

This report focuses on the innovation challenges at the research-industry nexus and the role of large companies in pursuing a technology-led recovery from COVID-19.

Translating research into scalable, commercial outcomes is within our reach if we overcome the barriers and focus on the enablers below.

Barriers to commercialisation		Enablers to overcome the barriers
Low levels of cross-sector collaboration This hinders both the translation of science and technology research into commercial outcomes and the adoption of new ideas from one sector to another.		**Collaboration** This is both an enabler in its own right and an important way to achieve some of the enablers. Collaboration helps to support early-stage research, translate and commercialise emerging science and technology, and increase adoption.
Lack of comprehensive innovation strategy and targeted investment Prevents industry achieving greater commercial outcomes at scale from science and technology.		**Long term strategy and targeted investment** The most successful innovating companies have a clear innovation strategy that supports their strategy and prioritises targeted areas of investment.
Culture, risk aversion and incentives misalignment A risk-averse cultural environment, with misaligned incentives, is less likely to support and invest in innovation, trial new processes, and adopt and implement new technologies.		**Culture, risk sharing and alignment of incentives** Innovation 'starts at the top', and companies that address the cultural aspects of innovation projects, as well as the alignment of incentives, are more likely to see their projects progress.
Talent and skills capability mismatches Skillsets are underutilised and misaligned in areas needed for commercialisation of emerging science and technology opportunities.		**Skills, talent and capability building** These are all required to successfully develop and deliver an innovation project.

1 Introduction

COVID-19 was an unprecedented shock to the Australian economy, but even in the years leading up to the pandemic the Australian economy was losing its momentum.

In the years leading up to the pandemic, there were concerning trends in Australia's economic fundamentals. Australia was experiencing low productivity, low business investment, and stagnation in several industries,[1] such as traditional large-scale manufacturing. It was also experiencing low levels of cross-sector collaboration and a cultural aversion to risk-taking,[2] both of which are essential to innovating.

If Australia takes decisive action now, it can leverage its advantages, embrace technological change and grow both existing and new markets.

A future-looking, resilient and advanced economy that stays ahead of these challenges is an economy that:

- continues to leverage its existing strengths but also diversifies its industrial base
- continues to invest in innovation, which has been shown to produce a huge return on investment
- progresses existing and new industries by embracing emerging technologies
- capitalises on opportunities to integrate itself into high-value global supply chains
- progresses towards reaching net-zero emissions by 2050[3]
- focuses on commercialising technology and scaling it through new company creation
- trains workforces with the necessary skills for the technologies of the future.

Diversifying the economy and trade:

A diversified economy is one that can produce and export a wide variety of goods and services, and one that has trade and investment relationships with a wide variety of countries. Despite its high level of income, there is a low level of diversity in Australia's industrial base, exports, and trade and investment relationships.[4] This leaves Australia at risk of being disrupted by new technologies and innovative competitors.

While Australia has greatly benefitted from the success of its traditional core industries, businesses cannot assume this will continue in the face of emerging technologies. The COVID-19 era has seen the acceleration of digital adoption. Machine learning, artificial intelligence, and automation are starting to have a transformative impact on supply chains. Similarly, innovative forms of renewable energy generation are likely to disrupt a familiar and long-established energy sector. New technologies, from future proteins to more sustainable and traceable production chains, are being adopted in food and agribusiness, while data-driven, agile, and tailored technology solutions are now found in sectors ranging from health to financial services to mineral resources.

Investing in innovation:

At the macro level, economists for decades have found empirical evidence that innovation is the dominant driver of long-run economic growth. Recent studies have estimated that at least 60% of Australia's overall productivity comes from innovation.[5] Advances in physical, mathematical, and biological sciences have been estimated to provide $330 billion to the Australian economy annually, equating to approximately 14% of the entire economy.[6] Moreover, two recent papers estimated that the social returns to innovation are very large and that, even under conservative assumptions, innovation investments produce social benefits that are many multiples of the investment costs.[7]

1 Ellis, L. (2021) Innovation and Dynamism in the Post-pandemic World. 18 November. Committee for the Economic Development of Australia Webinar.

2 Office of the Chief Economist (2016). Australian Innovation System Report 2016, Canberra. Available from: https://www.industry.gov.au/sites/default/files/May%202018/document/pdf/australian_innovation_system_report_2016_0.pdf?acsf_files_redirect

3 Australian Government (2021). Australia's Long-Term Emissions Reduction Plan; BCA (2021). Achieving a net zero economy; CSIRO. Towards net zero. Available from: https://www.csiro.au/en/about/challenges-missions/towards-net-zero..

4 Joint Standing Committee on Trade and Investment Growth. (2020) Pivot: Diversifying Australia's Trade and Investment Profile, Canberra. Seymour, H. (2020) Australia's Economic Diversification Imperative. Available from: https://perthusasia.edu.au/blog/australia%E2%80%99s-economic-diversification-imperative.

5 Office of the Chief Economist (2020). Australian Innovation System Monitor, Canberra. Available from: https://www.industry. gov.au/data-and-publications/australian-innovation-system-monitor.

6 Australian Academy of Science (2016). The importance of advanced physical, mathematical and biological sciences to the Australian economy, Canberra.

7 CSIRO (2021). Quantifying Australia's returns to innovation. Working Paper; Jones, B., Summers, L. (2020). A Calculation of the Social Returns to Innovation. NBER Working Paper No. 27863.

However, while Australia has a robust science and technology research system, its R&D expenditure remains lower than comparable economies.[8] Australia's national gross expenditure on R&D (GERD) as a percentage of GDP declined from 2.3% in 2008-09 to 1.8% in 2019-20.[9] This figure is low compared to top-performing innovative economies that spend on average over 3% annually on GERD proportional to GDP.[10] Australian GERD per capita is also below the OECD average and behind similarly sized economies, such as Belgium and the Netherlands.

There is an opportunity here for Australia to do better and for companies to benefit. 'Innovation-active' Australian companies (defined as companies that recently developed and/or introduced any type of innovation, including ones that are either still in progress or abandoned) are twice as likely to report increased productivity than non-innovating companies.[11] Almost all (89%) of 'innovative-active' companies are able to point to some kind of tangible benefit, whether it be improved customer service or increased revenue.

Embracing emerging technologies:

Going forward, emerging platform technologies such as artificial intelligence (AI), robotics, and synthetic biology can greatly enhance a wide range of commercial operations in existing industries in Australia, as well as support new Australian industries.

For example, although AI and automation are already available, there is still major scope to automate routine and some non-routine tasks.[12] Investments in these areas can enable companies to better utilise data, helping them to inform decision-making, improve processes and drive new efficiencies. Similarly, synthetic biology, which is the application of engineering principles and technologies to biological engineering, is a platform technology that could add value to both new and existing industries by enabling new products and biomanufacturing processes that could underpin the growth of an economic and environmentally sustainable bioeconomy.[13]

Integrating into high-value global supply chains

Science and technology innovation is important to the economy, not only because it creates new industries, but because it also enables established industries in Australia to become more integrated into global supply chains, such as through major value-adding opportunities. For instance, the Australian Government Modern Manufacturing Strategy[14] identified six domestic sectors that can increase their commercial potential through science and technology-enabled advanced manufacturing capabilities.

8 McKinsey & Company (2014). Compete to Prosper: Improving Australia's global competitiveness.; CSIRO (2020). Value of science and technology; CSIRO (2020). COVID-19: Recovery and resilience.; Global Innovation Index (2020). Australia – Economy analysis. Available from: https://www.globalinnovationindex.org/analysis-economy

9 ABS (2021) 8104.0 - Research and Experimental Development, Businesses, Australia, 2019-20, Canberra.

10 Industry Innovation and Science Australia (2016). Performance Review of the Australian Innovation, Science and Research System.

11 ABS (2020). 8167.0 – Characteristics of Australian Business, 2018-19. Available from: https://www.abs.gov.au/AUSSTATS/abs@.nsf/ DetailsPage/8167.02018-19?OpenDocument

12 CSIRO (2020). COVID-19: Recovery and resilience.; Australian Government (2020). Make it happen: The Australian Government's Modern Manufacturing Strategy, Canberra.

13 CSIRO. Synthetic Biology Future Science Platform. Available from: https://research.csiro.au/synthetic-biology-fsp

14 Australian Government (2020). Make it happen: The Australian Government's Modern Manufacturing Strategy, Canberra.

1 Resources technology and critical minerals processing

Opportunities for value-adding lie predominantly in resource technologies such as designing and producing remote vehicles and subsea technologies, and moving further up the critical minerals value chain by producing refined metals, pre-cursor chemicals, alloys and high-end engineered products through the adoption of advanced processing and refining.[15]

2 Food and beverage

The sector could capitalise on global demand for premium food and beverage markets by transforming the nutritional value and shelf life of local produce, and ensuring the safety, quality and provenance of its agrifood exports.[16] Key opportunities exist in alternative protein sources such as wheat, soy, pea and rice,[17] blockchain and DNA-testing for tracing and verification of origin and authenticity,[18] and new natural sweeteners, preservatives and nutraceuticals.[19]

3 Medical products

Demand for healthcare services is expected to rise from 10% of developed economies' GDP to 15% by 2030,[20] presenting a significant opportunity for Australia's pharmaceutical and medical technology industries. Specific opportunities include diagnostics and informatics products and services, vaccines, therapeutic products for emerging infectious diseases,[21] antibiotics,[22] and high-value medical technologies such as advanced monitoring devices and implants.[23]

4 Recycling and clean energy

Australia's emerging hydrogen industry presents significant clean energy opportunities. The country can also address local waste problems and meet the increasing global demand for sustainably produced goods through remanufacturing.[24] The Australian Government's Recycling Modernisation Fund, for instance, could help transform national waste and recycling, supporting new infrastructure to sort, process, and remanufacture materials and to establish a circular economy.[25]

5 Defence

The sector provides advanced technology (such as additive manufacturing, data and analytics, and the Internet of Things) with cross-sectoral applications, and delivers on national security imperatives as outlined in the Defence Industrial Capability Plan.[26] Australian defence manufacturers have the opportunity to enter some of the world's most advanced global supply chains and underpin national security.[27]

6 Space

Space technologies can support future economic growth and help companies make cost savings and advancements. Australian space manufacturing could create space components such as communication arrays, products that are launched into space such as small satellites, and associated products and infrastructure such as launch facilities.[28] Moreover, there are significant opportunities to draw in adjacent sectors, such as mining and resources, energy, and defence that are increasingly relying on space technologies and data.[29]

15 CSIRO (2020). COVID-19: Recovery and resilience.; Australian Government (2020). Make it happen: The Australian Government's Modern Manufacturing Strategy, Canberra.

16 Australian Government (2020). Make it happen: The Australian Government's Modern Manufacturing Strategy, Canberra.

17 CSIRO. Future Protein Mission: helping Australia capture high-growth global protein markets. Available from: https://www.csiro.au/en/about/challenges-missions/Future-protein-mission

18 CSIRO (2020). COVID-19: Recovery and resilience.

19 Ibid.

20 McKinsey & Company (2014). Compete to prosper: Improving Australia's global competitiveness.

21 CSIRO. Infectious Disease Resilience. Available from: https://www.csiro.au/en/about/challenges-missions/IDR-Mission

22 CSIRO. Antimicrobial Resistance. Available from: https://www.csiro.au/en/about/challenges-missions/Antimicrobial-resistance

23 CSIRO (2020). COVID-19: Recovery and resilience.

24 Australian Government (2020). Make it happen: The Australian Government's Modern Manufacturing Strategy, Canberra.

25 Minister for the Environment (2020). Joint Media Release: $1 billion waste and recycling plan to transform waste industry, Canberra. Available from: https://minister.awe.gov.au/ley/media-releases/1-billion-waste-and-recycling-plan-transform-waste-industry

26 Australian Government (2018). Defence Industrial Capability Plan. Department of Defence. Available from: https://www1.defence.gov.au/business-industry/capability-plans/defence-industrial-capability-plan

27 Australian Government (2020). Make it happen: The Australian Government's Modern Manufacturing Strategy, Canberra.

28 Australian Government (2020). Space National Manufacturing Priority road map: Vision and opportunities, Canberra. Available from: https://www.industry.gov.au/data-and-publications/space-national-manufacturing-priority-road-map/vision-and-opportunities

29 Ibid.

A low carbon economy:

One of the most important industry transitions this century will be in energy. Under current policies, the International Renewable Energy Agency estimates that total primary energy supply will increase over 30% by 2050.[30] In their meta-analysis of energy scenarios modelled by various organisations, they conclude that there is clear consensus on the importance of electrification powered by renewable energy sources in the global decarbonisation of the energy system. Notwithstanding the impacts of the COVID-19 pandemic, investment in energy transition technologies reached an all-time high in 2020. Nevertheless, greenhouse gas emissions are still rising, with energy-related CO2 emissions increasing globally by 1.3% on average annually between 2014 and 2019. This has a range of adverse impacts on the climate, health, food and water security, disaster risk management and the economy at large. Meeting global energy demand cleanly and cost-effectively will be a major global challenge.

Australia has a chance to leverage its abundant natural resources and technical expertise to become a world leader in clean energy and technology provision.[31] For example, Australia has the potential to develop the world's first clean hydrogen energy export market, with a combined value of around $11 billion a year in GDP by 2050.[32] Access to large scale, low-cost hydrogen energy can open new industry opportunities such as green steel manufacturing and hydrogen technologies and componentry.

Commercialising technology and scaling it through new company creation:

Australia's research translation capabilities appear to be mainly weighted on the research side rather than on commercialisation efforts.[33] Despite Australia's strong research output, it has among the lowest rates of conversion into patents, compounding the need for greater focus on commercialising new technologies.[34]

Commercialising new technologies through company creation can assist in generating jobs. Evidence shows new company creation is the predominant driver of growth in new jobs for Australia. From 2004 to 2014, 80% of net jobs growth in Australia was attributed to start-ups aged three years or younger.[35] Studies from other advanced economies reinforce these findings.[36] Supporting and partnering with entrepreneurs and start-ups to commercialise new science and technology opportunities will assist in creating jobs for Australians at a much-needed time.

Training workforces for the technologies of the future:

An economy that embraces new technologies will also need to develop a workforce that is skilled in those technologies. For Australia to make the most of a technology-enabled recovery, it will also need to confront the changing nature of skills that will be needed in the workforce of tomorrow. Companies can invest more in the skills and capabilities of their workforce, especially in STEM and digital capabilities.

30 International Renewable Energy Agency (2021). World Energy Transitions Outlook: 1.5°C Pathway. Available from: https://www.irena.org/publications/2021/Jun/World-Energy-Transitions-Outlook All other data from this paragraph is from this source.

31 Australian Government (2021). Australia's Long-Term Emissions Reduction Plan; CSIRO (2020). COVID-19 Recovery and resilience.

32 Minister for Energy and Emissions Reduction (2020). Fast tracking renewables hydrogen projects, Canberra.

33 Office of the Chief Economist (2016). Australian Innovation System Report 2016, Canberra. Available from: https://www.industry.gov.au/sites/default/files/May%202018/document/pdf/australian_innovation_system_report_2016_0.pdf?acsf_files_redirect

34 Cornell University, INSEAD, WIPO (2013). The Global Innovation Index 2013: The Local Dynamics of Innovation. Available from: https://www.wipo.int/edocs/pubdocs/en/economics/gii/gii_2013.pdf; it is important to acknowledge, however, that while not all science and technology is commercialised, some of it is translated into important non-commercial outputs.

35 Office of the Chief Economist (2017). Entrepreneurship Dynamics in Australia: Lessons from Micro-data. Research Paper 5/2017.

36 Ewing Marion Kauffman Foundation (2015). The importance of young firms for economic growth. Available from: https://www.kauffman.org/resources/entrepreneurship-policy-digest/the-importance-of-young-firms-for-economic-growth; Haltiwanger, J., Jarmin, RS., Miranda, J. (2013). Who creates jobs? Small versus large versus young. The Review of Economics and Statistics, 95(2), 347-361; Kuhn, JM., Malchow-Møller, N., Sørensen, A. (2016). Job creation and job types – new evidence from Danish entrepreneurs. European Economic Review, 86, 161-187.

This will enable workers to be globally competitive and better prepared for the technology-enabled jobs of the future. Likewise, companies themselves can learn how to apply current and emerging technologies, such as new digital technologies and other cross-cutting technological capabilities.

If Australian companies do not take these steps, the nation risks being left behind.

Modelling from CSIRO's *Australian National Outlook 2019* showed that decisive transformational change of Australia's broader economy, society, and environment, and the adoption of technology are critical to driving productivity and economic growth in Australia.

The ANO report modelled two contrasting scenarios (*Outlook Vision* and *Slow Decline*) that are plausible, evidence-based narratives exploring a range of causes and effects, as well as the trade-offs between different outcomes. In the *Outlook Vision* scenario, Australia reaches its full potential. Economic growth remains strong and inclusive as Australian companies use technology to move productivity towards the global frontier and create new globally competitive, export-facing industries. Improved educational outcomes give Australians the skills they need to compete in this technology-enabled workforce. Under this scenario, Australians feel secure and empowered to prosper.

By contrast, in the *Slow Decline* scenario, Australia fails to take strategic action and drifts into the future under business as usual. Economic growth, investment and education outcomes are all relatively weak. Australia's economy is increasingly vulnerable to external shocks. Total Factor Productivity (TFP) growth remains well below the global frontier and wage growth is relatively low. Australians remain worried about their livelihoods and job security.

The difference between the scenarios is significant and the positive outlook is worth striving for:

- **Productivity:** Australia's annual increase in TFP has ranged widely over the past three decades, averaging 0.6%. Under the *Outlook Vision* scenario, Australia achieves its full potential with a technology-enabled workforce and private sector, and Australia rises steadily to almost 2% productivity in 2060. In contrast, under the *Slow Decline* scenario, economy wide TFP growth in Australia remains stuck below 1%.
- **GDP:** GDP per capita in 2060 would be 33–36% higher in the *Outlook Vision* scenario than in the *Slow Decline* scenario with over half the difference coming from technology-fuelled increases in productivity. In real terms, this equates to a GDP of $5.5–5.6 trillion for the *Outlook Vision*, compared with $4.1 trillion for *Slow Decline*.
- **Technology:** The TFP performance also brings Australia closer to the current productivity frontier (the maximum or theoretical productivity achievable), relying on Australia's traditional strengths and creating new ones through the adoption of globally competitive technology and expertise.[37] If this productivity level is to be met, it will depend in large part on the adoption of a range of technologies including digital, mechanical and human processes. This broad technology adoption is the most important differentiator between national economic performances,[38] and accounts for at least one-quarter of real per capita income growth.[39]

37 CSIRO (2019). Australian National Outlook 2019.

38 Gancia, G., Zilibotti, F. (2009) Technological change and the wealth of nations. Annual Review of Economics, 1, 93–120.

39 Comin, D., Hobijn, B. (2010) An exploration of technology diffusion. American Economic Review, 100, 2031–59.

This report focuses on the practical steps to overcome barriers to commercialisation for a technology-led economic recovery from COVID-19.

This report does not attempt to solve all of the challenges facing Australia. Instead, it focuses on the innovation challenges at the research-industry nexus and the role of large companies in pursuing a technology-led recovery from COVID-19. To achieve this recovery, Australia needs to improve its translation of commercial outputs from science and technology, and Australian companies play an important role in making this happen. The report is intended to inform high-level discussions among senior leaders in Australia about evidence-based and implementable steps that Australia can pursue now to realise this recovery.

This report follows from CSIRO's *Australian National Outlook 2019, COVID-19: Recovery and Resilience* and *Value of science and technology* reports. They explored not only why science and technology matters but also why Australia needs to achieve greater commercial outputs from science and technology and which of these opportunities it should prioritise. This report focuses on the role of large Australian companies here.[40]

The findings combine desktop research with insights from consultations with targeted Business Council of Australia (BCA) members. Success stories from BCA members are highlighted in this report to demonstrate the practical actions that Australian companies can take to achieve greater commercial outputs from science and technology, including gaining competitive advantage, building capability, driving technology development and adoption, and accessing new markets and growth opportunities.

40 With regards to smaller Australian companies and their perceived enablers and barriers to working with the research sector, please see the recent report: CSIRO and RMIT (2021). Enablers and barriers to industry-research collaboration; A small and medium sized enterprise (SME) perspective.

Chapter 2 demonstrates that for Australian companies, the barriers to commercialisation include lower levels of business-research collaboration compared to international peers, a lack of national-scale, long term innovation strategy development and targeted investments; and cultural factors such as risk aversion; and skills, talent and capability mismatches.

Chapter 3 explains that while many of these barriers cannot be addressed directly by companies alone, for each of these barriers, there are corresponding enablers that companies can leverage to progress along the commercialisation pathway more effectively and efficiently. Companies can:

- collaborate more in supporting early-stage research, translating and commercialising emerging science and technology, and adopting commercially available technology to build local capability and gain competitive advantage.
- pursue long term strategies and make targeted investments in innovation projects to gain competitive advantage, access new markets and enjoy growth and efficiency benefits.
- embrace a 'growth through innovation' culture and openly discuss the sharing of risk and intellectual property (IP) with their innovation partners to successfully drive the development and adoption of new technologies.
- actively build skills and capability in Australia both in emerging research areas as well as broader digital capabilities for competitive advantage.

2 Barriers to commercialisation of science and technology

Australia's difficulty in achieving greater commercial outputs from science and technology stem from several complex factors,[41] however the most notable barriers raised during consultations with BCA members were:

- **Low levels of cross-sector collaboration** in science and technology innovation compared to international benchmarks.
- **A lack of comprehensive innovation strategy and targeted science and technology investment** at the national level, along with an absence of coordinated and ambitious planning.
- **Cultural challenges**, including risk aversion to innovation and business-research incentives misalignment.
- **Talent and skills underutilisation and mismatch** in areas needed for commercialisation of emerging science and technology opportunities.

2.1 Low levels of cross-sector collaboration

Low levels of cross-sector collaboration hinder both the translation of science and technology research into commercial outputs and the adoption of new ideas from one sector to another. Despite proven benefits, cross-sector and business-research collaboration in Australia is modest.[42] Although collaboration strategies do exist in Australia (see Section 3.1 for a detailed list of existing formal collaboration mechanisms), these would benefit from greater promotion and increased support.[43]

According to the OECD's most recent international comparisons of innovation indicators, Australia ranks last among OECD countries for the proportion of companies that collaborate with higher education and government institutions on innovation.[44] While the OECD indicators are just one of many international metrics in this space and have methodological limitations, they provide a useful pulse check on cross-country innovation performance. Furthermore, Australia suffers from ineffective clustering and networking of innovation activities[45] and most industries have low levels of beneficial agglomeration effects (i.e. productive advantages that arise from the spatial concentration of economic activities).[46] Low levels of collaboration are noted by the findings of the most recent ABS Business Characteristics Survey.

41 For a detailed discussion please see CSIRO (2020). Value of Science and Technology.

42 Office of the Chief Economist (2016). Australian Innovation System Report 2016, Canberra. Available from: https://www.industry.gov.au/sites/default/files/May%202018/document/pdf/australian_innovation_system_report_2016_0.pdf?acsf_files_redirect.

43 Office of the Chief Economist (2016). Australian Innovation System Report 2016, Canberra. Available from: https://www.industry.gov.au/sites/default/files/May%202018/document/pdf/australian_innovation_system_report_2016_0.pdf?acsf_files_redirect

44 OECD (2020). Innovation Indicators, OECD Publishing.

45 CSIRO (2020). Value of Science and Technology.

46 ABS (2017). 1504.0 – Methodological News, Dec 2017, Estimating Agglomerations Elasticities for Wider Economic Benefits of Transport Projects. Available from: https://www.abs.gov.au/AUSSTATS/abs@.nsf/Previousproducts/1504.0Main%20Features3Dec%202017?opendocument&tabname=Summary&prodno=1504.0&issue=Dec%202017&num=&view=; KPMG (2017). Measuring WEBS in Australian Cities (prepared for Australian Bureau of industry, Transport and Regional Economics).

Collaboration findings from the ABS Business Characteristics Survey (2018-19)

This survey examined the extent and nature of collaborative arrangements for companies, as well as the barriers to collaboration that they encountered.[47]

- **Level of collaboration:** Just over 14% of all companies in Australia, irrespective of industry or employment size, collaborated for the purposes of innovation in 2018-19. Among larger companies with 200 or more employees, this proportion was only slightly higher, at almost 18%.
- **Collaboration partnerships:** For Australian companies that did collaborate on innovation, the main partnerships were with suppliers of equipment, materials, components of software (40%), clients and customers (41%), consultants (29%), and competitors and other companies from the same industry (27%).
- **University and research collaboration:** Only 10% of companies that collaborated did so with universities or other higher education institutions, and around 13% of these companies did so with other research institutions. For larger companies with 200 or more employees that engaged in innovation collaboration, around 14% did so with universities or other higher education institutions, and around 18% did so with other research institutions.
- **Barriers cited:** The main factors reported that prevented or limited collaboration for companies was insufficient time (20%) and insufficient funds (19%).

Interestingly, 56% of all companies, and 72% of larger companies with 200 or more employees, did not cite a reason from the list of factors presented by the survey. This potentially suggests that companies face a range of less tangible or complex factors that prevent or limit their collaboration. Some broader, more complicated factors are explored in the rest of this chapter.

There is evidence Australia underperforms in international collaboration efforts. Australia recently ranked 84th globally for GERD financed by foreign partners,[48] and only 7% of Australia's innovation-active companies engaged in international collaboration.[49] Most innovations that are adopted and diffused already existed in the domestic Australian market, indicating that companies are not looking beyond borders to collaborate on innovation.[50]

BCA stakeholders noted their collaboration challenges also differed depending how far along the innovation cycle they were operating. In collaborating to support early-stage research, consultees faced obstacles in locating the right people in large and complex research organisations and in agreeing how to share project risks. When commercialising emerging science and technology, consultees noted they struggled to align incentives and skillsets in their partnerships with external companies and research organisations. In adopting commercially available technology in partnerships with providers, consultees occasionally came across difficulties developing the capabilities necessary to successfully implement and deploy these innovations.

47 ABS (2020). Characteristics of Australian Business Methodology: 2018-2019 financial year, Canberra. Available from: https://www.abs.gov.au/methodologies/characteristics-australian-business-methodology/2018-19

48 Global Innovation Index (2020). Analysis Indicator. Available from: https://www.globalinnovationindex.org/analysis-indicator

49 OECD (2019). Business innovation statistics and indicators. Available from: https://www.oecd.org/sti/inno/inno-stats.htm

50 ABS (2019). 8167.0 – Characteristics of Australian Business, 2018-19. Available from: https://www.abs.gov.au/AUSSTATS/abs@.nsf/ DetailsPage/8167.02018-19?OpenDocument

2.2 Lack of comprehensive innovation strategy and targeted investment

Several of the BCA members consulted described Australia's research translation and commercialisation landscape as fragmented, uncoordinated, and lacking in sufficient scale. They emphasised a lack of consistent and ambitious national strategy and planning as a barrier to industry achieving greater commercial outputs from science and technology.

For instance, in the battery chemicals and battery manufacturing market, BCA members agreed that while Australia has "all the ingredients to become a major player" in the global market, there is a lack of strategic emphasis and planning to become competitively significant in these technology opportunities. While current initiatives may provide sufficient investment to drive some smaller projects forward, consultees believed more targeted government co-investment is necessary to drive the larger collaborative ventures needed to strategically position Australia in the global market.

Complicating this situation, research-industry partnership agreements often struggle to satisfy expectations of both sides. Several BCA members observed that negotiating ownership over the IP developed during innovation activities with Australian research organisations is particularly challenging as both parties seek to retain as much of the IP as possible. As such, it can take significant effort to reach a commercial agreement that meets the expectations of both parties involved.

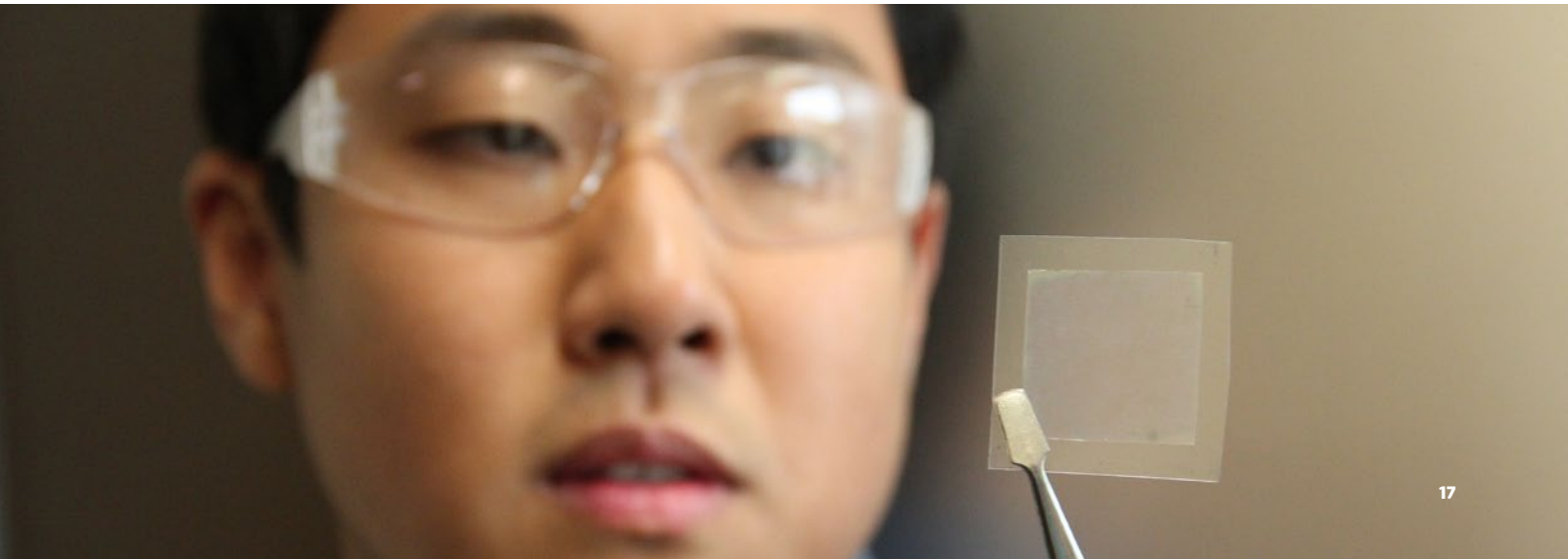
In addition to these strategic and investment barriers, BCA members identified policy and regulatory barriers that either slow down science and technology commercialisation at scale domestically or lead to companies choosing to commercialise overseas instead. Consultees also cited various policy and regulatory challenges around competing against international competitors.

Policy and regulatory barriers to achieving commercial outputs from science and technology

BCA members believed government bodies could play a greater role in providing leadership direction and policy certainty on national-level economic development. For example, one consultee noted that there was no single source of ministerial responsibility around digitisation policy. It was generally acknowledged that policy coordination and certainty in areas such as energy or digital uptake, such as through ongoing government signalling to the business community, could significantly help companies with their decision-making around science and technology investments.

One member noted that Australia needs to find ways to make innovation risk-taking "more palatable" for domestic companies, with government and research needing to create incentives like other overseas jurisdictions with strong collaboration models (see Section 3.1). The member suggested one potential role of government could be to create a more "level playing field" in strategic technologies, such as new energy technologies, so that companies can compete more effectively on the international market.

In terms of regulation, some consultees noted the existence of regulatory barriers in Australia that hinder innovating at a globally competitive level, including delays and costs in moving new products and services through the regulatory cycle. A BCA member noted that these factors mean Australian companies are often incentivised to have early-stage products approved by regulators overseas which, in turn, make it more advantageous to manufacture the product overseas as well, thus excluding Australia from the collaboration-commercialisation pathway.



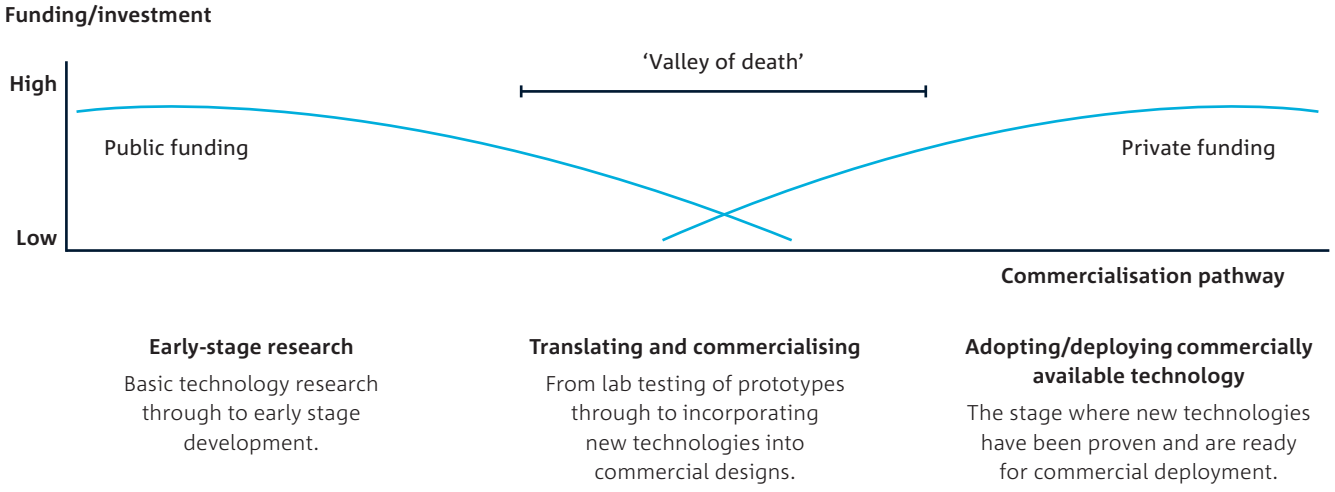
Another major challenge to commercialisation at scale that is exacerbated by the lack of concerted strategy and targeted investment is the concept of the 'valley of death'. While there are often strong levels of public sector investment in early-stage research and strong levels of private sector investment in the late-stage commercialisation of proven technologies, there is often a gap in investment in the middle stages of technology development.[51] This investment gap is known as the 'valley of death' where, because of a disconnect between research and industry, there can be insufficient public or private investment or support to advance research discovery to a final commercial product.[52] A stylised version of this 'valley of death' in the innovation system is depicted below in Figure 2.1.

As noted by both some stakeholders and by the innovation literature, without significant investment, effort, and risk taking to better integrate research with industry application in the middle stages, promising science and technology opportunities can fail to progress.

2.3 Culture, risk aversion, and incentives misalignment

Australia has arguably developed an increasingly risk-averse culture, including among its companies, creating a growing innovation gap between Australia and emerging economies that are more willing to take risks.[53] When innovating, the majority of Australian companies source their ideas from within the business, and few innovations are new to Australia, let alone new to the world.[54] The Governor of the RBA has noted that Australia's "preferences appear to have shifted in such a way that we increasingly focus on risk mitigation and risk control".[55] The implication of this is that a more risk-averse culture is less likely to support and invest in innovation, trial new processes, and adopt and implement new technologies.[56] One BCA member believed Australian companies have a low appetite to develop high risk-high reward 'blockbuster' technologies. This risk-averse culture stands in contrast to world-class examples of business creativity and flexibility, such as the Silicon Valley model where cultural norms that encourage company risk-taking and accepts the possibility of failure have stimulated significant entrepreneurial activity.[57]

Figure 2.1: The 'valley of death' in the commercialisation pathway



Source: Adapted from Chirazi et al. (2019)

51 Markham S., Ward S., Aiman-Smith, L., Kingon, A. (2010). The Valley of Death as Context for Role Theory in Product Innovation. Journal of Product Innovation Management, 27(3), 402-417; Chirazi, J., Wanieck, K., Fayemi, P., Zollfrank, C., Jacobs, S. (2019). What Do We Learn from Good Practices of Biologically Inspired Design in Innovation? Applied Science, 9(4), 650.

52 Bhushan, B. (2015) Perspective: Science and technology policy – What is at stake and why should scientists participate? Science and Public Policy, 42(6), 887-900.

53 Deloitte Access Economics (2014). Australia's innovation imperative: Business Council of Australia. Available from: https://www2.deloitte.com/content/dam/Deloitte/au/Documents/strategy/deloitte-au-con-bca-report-0914.pdf

54 ABS (2018). 8158 - Innovation in Australian Business, 2016-17, Canberra.

55 Reserve Bank of Australia (2014). Speech: Demographics, Productivity and Innovation. Available from: https://www.rba.gov.au/speeches/2014/sp-dg-120314.html

56 Ibid.

57 Deloitte Access Economics (2014). Australia's innovation imperative: Business Council of Australia. Available from: https://www2.deloitte.com/content/dam/Deloitte/au/Documents/strategy/deloitte-au-con-bca-report-0914.pdf

One BCA member summarised the cultural challenges in Australian innovation as including the prioritisation of delivering financial results over an innovation culture, a reluctance to explicitly support and invest in dedicated innovation roles, and a lack of publicised success stories showing how Australian companies are successfully building and leveraging innovation culture.

Consultations also revealed that many other cultural barriers to collaborative innovation exist between industry, research, and government partners. These include cultural factors at the leadership level, with cross-sector dialogue, and incentives misalignment between the industry and research systems.

One BCA member argued that business growth and innovation are fundamentally about mindset and culture, with many of the barriers being around vision and ambition. They believed that there needs to be a greater understanding of technology and science and its potential at the leadership level.

Another BCA member described fundamental challenges in developing a shared language to foster collaboration and discussions between industry and research, to explore mutual areas of research interest, and to drive towards a more formal partnership. They believed researchers with deep expertise in technical research, for example, can become defined by the language in their field, creating a barrier to external conversations with potential industry commercialisation partners.

Another perspective from some BCA members was that the incentives of industry and research organisations were often not aligned with each other. One BCA member stated that their "default" preference was to collaborate with other industry partners with in-house research translation and commercialisation capabilities rather than research organisations, in part because the commercial drivers and incentives of industry partners were more closely aligned. They noted that a commercial arrangement between two private sector entities was easier to establish, even if each brings different objectives, and that the potential commercial returns on higher risk investments from private sector collaboration were preferable for them.

2.4 Talent and skills capability mismatches

While impressive STEM talent is abundant in Australia, these skillsets are underutilised and misaligned in areas needed for commercialisation of emerging science and technology opportunities. Australia is ranked among the OECD countries with the most acute in-country skill mismatches in 2016.[58] These skills shortages are more pronounced in innovation-active companies than non-innovation-active companies across skills types.[59]

At the leadership level, there is a shortage of Australian technologists and senior management with skills to lead through technological transformations and breakthrough innovations.[60] This is especially the case for new-to-market products, driven in part by a "brain drain" of young talent whereby only half of scientific and technical services graduates ultimately pursue STEM-focused careers and instead enter into other industries.[61] One estimate suggests Australia is forgoing $57.4 billion in GDP over 20 years that could be realised by shifting just 1% of its workforce into STEM roles across major industries.[62] Consultees confirmed there was subdued retention of STEM staff, with both research organisation and company personnel often changing throughout an innovation project, which can hinder the delivery of medium to long-term commercial outputs from science and technology.

Moreover, the integration of researchers in the private sector is not commonplace in Australia, as only 30% of researchers are based in industry compared to over 70% in Korea, Japan, and the US.[63] BCA stakeholders observed that there is both insufficient industry utilisation of Australian academics and insufficient academic participation with Australian companies. They indicated that Higher Degree Research students in Australia are also far less involved in companies than in other countries and that there are fewer incentives in the academic system to encourage them to contribute to commercialisation activities. Other consultees cited low support provided to Australian entrepreneurs compared to research organisations in the US, Europe, and Asia, as well as how other countries have better extended their capability to draw on international talent to support science and technology endeavours (for more details of these overseas examples, refer to Section 3.1). This lack of business-research talent sharing again hinders the translation of science and technology research into commercial outputs.

58 OECD (2021). Mismatch. Available from: https://stats.oecd.org/Index.aspx?DataSetCode=MISMATCH

59 Office of the Chief Economist (2016). Australian Innovation System Report 2016, Canberra. Available from: https://www.industry.gov.au/sites/default/files/May%202018/document/pdf/australian_innovation_system_report_2016_0.pdf?acsf_files_redirect

60 CSIRO (2020). Value of science and technology.

61 Monash University (2017). How Do We Fix STEM's Brain Drain? Available from: https://www2.monash.edu/impact/articles/economy/how-do-we-fix-stems-brain-drain/

62 PwC (2015). A smart move: Future-proofing Australia's workforce by growing skills in science, technology, engineering and maths (STEM). Available from: https://www.pwc.com.au/pdf/a-smart-move-pwc-stem-report-april-2015.pdf

63 OECD (2016). Main Science and Technology Indicators. Available from: https://stats.oecd.org/Index.aspx?DataSetCode=MSTI_PUB

3 Enablers to overcome the barriers to commercialisation

The scope for this report does not include the action by government and research stakeholders. This can be found elsewhere, including in the BCA's many budget submissions and reports.

This chapter focuses on the practical actions that Australian companies can take themselves to overcome some of the barriers to commercialisation, especially at scale within the economy, and ultimately achieve better commercial outputs from science and technology. The following key enablers directly align to the barriers discussed in Chapter 2:

- **Collaboration**: this is both an enabler in its own right and an important way to achieve some of the enablers listed below. For example, collaboration helps to support early-stage research, translate and commercialise emerging science and technology, and increase adoption, but it also helps to share risk among innovation partners and build capabilities.
- **Long term strategy and targeted investment:** the most successful innovating companies have a clear innovation strategy that supports their business strategy and prioritises targeted areas of innovation investment to gain competitive advantage.
- **Culture, risk sharing and incentives alignment:** innovation 'starts at the top' with senior executives championing innovation, and companies that openly address the cultural aspects of innovation projects, including the allocation of risks and IP, as well as the alignment of incentives, are more likely to see their projects progress through the innovation cycle.
- **Skills, talent, and capability building:** these are all required to successfully develop and deliver an innovation project, and companies need to decide whether to develop these in-house or source through an external partner.

The rest of this chapter draws on BCA member insights and success stories to illustrate how the four enablers improve commercial outputs from science and technology.

3.1 Collaboration

Collaboration was discussed by the BCA members as both an enabler in its own right and an important way to achieve some of the other enablers. For example, stakeholders noted that collaboration helps to support early-stage research, translate and commercialise emerging science and technology, and increase adoption, but it also helps to share risk among innovation partners and build capabilities. Given this dynamic nature of collaboration, this enabler has been examined in more detail than the other three enablers.

As an enabler in its own right, collaboration is a demonstrated trait of top-performing companies and enables them to maximise growth. In particular, the CSIRO-UQ *Thriving through innovation survey* found that top-performing companies collaborate broadly across several stakeholder groups, including business-business collaboration with suppliers and customers, as well as business-research collaboration with university partners, public and private research organisations, and business-government collaboration.[64] It was this breadth of collaboration that was identified as the single clearest driver of performance when compared to other process-related variables, and was 11 times higher for the top-performing companies compared to average-performing companies.[65] Stakeholders consulted note that maintaining long-term relationships is essential here, whereby all relationships do not need to remain active but merely ticking over.

64 CSIRO (2020). Thriving through innovation: lessons from the top.

65 Ibid.

Business-research collaboration improves the translation of science and technology research into successful commercial outputs.[66] It also improves the alignment of skillsets and incentives of both research and industry towards commercialisation,[67] fosters an innovation culture, allows greater risk sharing, and promotes wider applications and impact of ground-breaking innovations. One way that companies and research organisations are stimulating collaboration is by embedding researchers within industry. This improves the development side of R&D and promotes the successful transfer of ideas and the co-creation of new ideas between research and industry. Similarly, start-ups founded by academic researchers significantly contribute to the commercialisation of knowledge generated through public research and lead to more patents than non-academic start-ups.[68]

This collaboration does not have to be solely domestic since significant value can also be captured from international collaboration. Australian companies can increase their share in global markets and experience productivity growth by positioning themselves in high-value niche segments within global value chains and extend international partnerships. By moving from global competition to global collaboration, companies can grow their international exposure, enabling them to maintain or improve market share, innovate more, improve management quality, and enjoy double productivity growth compared to companies with low international exposure.[69]

During the consultations, most of the BCA members said they were familiar with some but not all of the formal mechanisms available in Australia for business-research collaboration.

66 Industry Innovation and Science Australia (2019). Australia 2030: Prosperity through Innovation, Canberra. Available from: https://www.industry.gov.au/sites/default/files/May%202018/document/pdf/australia-2030-prosperity-through-innovation-full-report.pdf?acsf_files_redirect

67 CSIRO (2020). Value of Science and Technology.

68 Ibid.

69 Office of the Chief Economist (2014). Australian Innovation System Report, Canberra. Available from: https://www.industry.gov.au/sites/default/files/May%202018/document/pdf/australian_innovation_system_report_2014.pdf?acsf_files_redirect; Office of the Chief Economist (2016). Australian Innovation System Report 2016, Canberra. Available from: https://www.industry.gov.au/sites/default/files/May%202018/document/pdf/australian_innovation_system_report_2016_0.pdf?acsf_files_redirect

Formal mechanisms in Australia for business-research collaboration

Many formal collaboration mechanisms currently exist in Australia to strengthen business-research collaboration. These include research-led, industry-led and government facilitated mechanisms that aim to foster cross-sector collaboration and improve the ease and frequency of joint participation:

- **The Research and Development Tax Incentive:** This is the government's key mechanism for increasing private R&D activity and aims to provide a way for companies to invest in R&D by alleviating key barriers that lead to underinvestment, such as not being able to capture the benefits of their R&D due to spillover effects and difficulty finding external finance due to the risk associated with their R&D projects.[70]
- **Entrepreneurs' Programme Innovation Connections:** This is the Australian Government's flagship initiative that provides practical support for companies concerning their competitiveness and productivity. It spans activities such as project commercialisation and funding, business growth and innovation research.[71]
- **The Cooperative Research Centres (CRC) Program:** The CRC Program aims to partner industry with the research sector to solve industry-identified issues. CRC Programs have been successful in providing grants to co-fund industry-led research, emphasising the importance of collaborative arrangements and an enhanced process of utilisation, commercialisation, and technology transfer, focusing on producing graduates with skills relevant to industry needs.
- **Industry Growth Centres:** Growth Centres identify industry knowledge priorities to inform researchers of industry needs and demands, commercialisation opportunities and priorities for research programs led by industry. These centres also develop trade and investment promotion strategies and inform the improvement of workforce skills through collaboration with the Australian Industry Skills Committee and Industry Reference Committee.[72]

  Examples of Growth Centres include the Advanced Manufacturing Growth Centre (AMGC), which is working with the industry to drive cultural change, unlock new commercial opportunities and foster innovation and competitiveness, and the Cyber Security Growth Centre (AustCyber), which aims to increase collaboration, innovation and participation in globally competitive markets as well as build capability.[73]
- **Innovation Precincts:** These precincts or clusters allow companies to better position themselves in global and local value chains and accelerate cross-sector collaboration, targeted development and innovation diffusion.[74] An example is the Swinburne Innovation Precinct, which incorporates many research, industry and other investment partners and focuses on advanced manufacturing, design innovation and digital transformation.[75]
- **National Innovation Games:** Launched in 2019, the National Innovation Games have participants find innovative and practical solutions to an identified business challenge by connecting STEM graduates with industry needs.[76]
- **The Global Innovation Linkages and Global Connections Fund:** The Fund supports international collaboration on cutting-edge and strategically focused research translation and commercialisation projects that develop products, services or processes that respond to industry challenges.[77] For example, the Fund has provided a grant to an international consortium to support the clinical transition of a new-to-market diagnostic technology that improved cancer detection.[78]
- **The ARC Industrial Transformation Research Program:** This program seeks to attract both university-based researchers and companies. It achieves this by funding research hubs and training centres whilst providing research students practical skills and experience through placement in industry.[79]

70 Australian Government. Research and Development Tax Incentive, Canberra. Available from: https://www.industry.gov.au/funding-and-incentives/research-and-development-tax-incentive

71 Australian Government. Entrepreneurs' Programme, Canberra. Available from: https://www.business.gov.au/grants-and-programs/entrepreneurs-programme#innovation-connections

72 Australian Government. Collaboration between government and industry, Canberra. Available from: https://www.industry.gov.au/data-and-publications/industry-growth-centres-initiative-progress-and-impact/collaboration-between-government-and-industry

73 Australian Government. Industry Growth Centres, Canberra. Available from: https://www.industry.gov.au/policies-and-initiatives/industry-growth-centres

74 Australian Government. Promoting innovation precincts, Canberra. Available from: https://www.industry.gov.au/policies-and-initiatives/promoting-innovation-precincts ; CSIRO (2020). Value of science and technology.

75 IC Global. Innovation Map. Available from: https://innovationmap.global/

76 Australian Government (2019). Let the National Innovation Games begin, Canberra. Available from: https://www.industry.gov.au/news/let-the-national-innovation-games-begin

77 Australian Government. International research collaboration. Available from: https://www.industry.gov.au/funding-and-incentives/international-research-collaboration

78 Australian Government (2020). Better Diagnostic Technology for Cancer Detection, Canberra. Available from: https://www.industry.gov.au/data-and-publications/better-diagnostic-technology-for-cancer-detection

79 Australian Research Council (2020). Industrial Transformation Research Program, Canberra. Available from: https://www.arc.gov.au/grants/linkage-program/industrial-transformation-research-program

More so than the other enabler categories, the BCA members noted that the types of collaboration needed to achieve better commercial outputs from science and technology differ across the innovation cycle. One useful way to conceptualise this is through the Technological Readiness Levels (TRL) framework, as seen in figure 3.1, which characterises the innovation cycle into 9 process stages:

- **Supporting early-stage research in low-TRL stages (TRL 1 to TRL 3):** collaboration activities tend to involve participating in pre-competitive/commercial and public good activities such as national scale missions and building capability and talent at the industry level and for the broader innovation ecosystem.
- **Translating and commercialising emerging science and technology in mid-TRL stages (TRL 4 to TRL 8):** collaboration activities typically focus on business-research collaboration to successfully integrate science and technology into commercial designs and into existing suites of technologies and to gain competitive advantage. This stage along the innovation cycle was acknowledged in consultations as the most crucial to achieving better commercial outcomes from science and technology because it is the one that is most prone to major, project-ending barriers. This alludes to the notion of the 'valley of death' in the innovation cycle (as previously discussed in section 2.2), defined as a period of technology development where significant increases in investment, effort and risk taking are needed to integrate the research into a commercial industry application at scale.
- **Adopting commercially available technology in high-TRL stages (TRL 9):** collaboration activities tend to focus on business-business collaboration to implement and adopt now-proven and commercially available technologies into company operations, including across sectors, to gain competitive advantage.

Figure 3.1: Technological Readiness Levels (TRL) framework

This framework can be divided into three segments:

9	Technology proven and ready for full commercial deployment	High-TRL
8	Technology incorporation into commercial design	Mid-TRL
7	Integrated pilot technology demonstration	
6	Prototype technology verification	
5	Lab testing of integrated/ semi-integrated technologies	
4	Lab testing of prototype components/processes	
3	Early stage development	Low-TRL
2	Applied technology research	
1	Basic technology research	

CASE STUDIES

The following case studies illustrate how BCA members are collaborating to support early-stage research, translate and commercialise emerging science and technology, and adopt commercially available technology to build local capability and gain competitive advantage.

Boeing

Key insights: Boeing's commercialisation of emerging uncrewed aircraft technology helped it and the Royal Australian Air Force gain competitive advantage while also building local capability.

Through strong industry collaboration and in-house research translation and commercialisation efforts, Boeing designed, developed and manufactured the Loyal Wingman aircraft in partnership with the Royal Australian Air Force. This is Boeing's largest investment in an uncrewed aircraft outside of the US and the first aircraft to be designed, engineered, and manufactured in Australia in more than 50 years.[80]

In response to growing global defence market demand for highly capable but affordable uncrewed aircraft,[81] Boeing uses artificial intelligence to extend the capabilities of crewed and uncrewed platforms. The aircraft not only performs like a fighter jet but has other roles including electronic warfare, intelligence, surveillance, and reconnaissance alongside crewed aircraft.[82]

Boeing collaborated with over 35 Australian-based companies, which was key to the program's rapid development. These companies included BAE Systems Australia, which delivered flight control computers and navigation equipment, RUAG Australia, who delivered the landing gear system, Ferra Engineering, who provided the precision machine components and sub-assemblies to support the program, and AME Systems, who delivered wiring looms.[83] Much of the development of the technology, from concept to commercial application, occurred in the virtual space, with Boeing utilising the 'digital twin' concept – a highly detailed virtual model of the aircraft – for testing, development and training.[84]

Boeing benefits from the development of this technology in Australia, with the Loyal Wingman aircraft serving as the foundation for the global Boeing Airpower Teaming System. For Australia, the collaboration activities strengthen local aircraft manufacturing capabilities and infrastructure as well as the national defence market, with BAE Systems Australia stating that the collaboration also helped to grow their Autonomous Systems and Advanced Payload groups.[85]

Cochlear

Key insights: Cochlear's support of early-stage implant research is enabling the commercialisation of new implant therapies for epilepsy and sleep apnoea.

Identifying a lack of implant therapies for conditions such as epilepsy and sleep apnoea, Cochlear saw an opportunity to leverage their deep expertise in implant technologies for hearing impairment by supporting the commercialisation of new therapies. Cochlear collaborated with universities and early-stage technology companies on pre-competitive activities to explore and develop these new implant therapies. This included a $3.65 million early-stage investment in a breakthrough epilepsy monitoring device produced by The Bionics Institute in collaboration with St Vincent's Hospital and the University of Melbourne.[86] Cochlear has also invested in a nerve stimulation treatment for sleep apnoea developed by Belgium-based Nyxoah.[87] These investments have the potential to address both the clinical and market need for implant therapies related to medical conditions that affect millions of people worldwide.[88]

80 Freed, J. (2019). Boeing unveils unmanned combat jet developed in Australia, Reuters. Available from: https://www.reuters.com/article/us-australia-airshow-boeing-unmanned/boeing-unveils-unmanned-combat-jet-developed-in-australia-idUSKCN1QF2XT

81 de Git, M., Erwin, A. (2020). Boeing rolls out first Loyal Wingman unmanned aircraft, Boeing. Available from: https://www.boeing.com.au/news/releases/2020/may/boeing-rolls-out-first-loyal-wingman-unmanned-aircraft.page

82 Freed, J. (2019). Boeing unveils unmanned combat jet developed in Australia, Reuters. Available from: https://www.reuters.com/article/us-australia-airshow-boeing-unmanned/boeing-unveils-unmanned-combat-jet-developed-in-australia-idUSKCN1QF2XT

83 de Git, M., Erwin, A. (2020). Boeing Australia Completes First Loyal Wingman Fuselage, Boeing. Available from: https://boeing.mediaroom.com/2020-02-09-Boeing-Australia-completes-first-Loyal-Wingman-fuselage#assets_20295_130618-117

84 Rogoway, T. (2020). Everything We Learned From Boeing About Its Potentially Game-Changing Loyal Wingman Drone, The Drive. Available from: https://www.thedrive.com/the-war-zone/33271/everything-we-learned-from-boeing-about-its-potentially-game-changing-loyal-wingman-drone

85 BAE Systems (2020). BAE Systems Australia supports Boeing's Loyal Wingman Australian industry team. Available from: https://www.baesystems.com/en-aus/article/loyal-wingman-milestone-welcomed-by-bae-systems-australia

86 Bionics Institute. Breakthrough epilepsy monitoring device receives investment funding. Available from: https://www.bionicsinstitute.org/news/breakthrough-epilepsy-monitoring-device-receives-investment-funding; University of Melbourne. Improving epilepsy diagnosis with a wearable device. Available from: https://research.unimelb.edu.au/work-with-us/case-studies/improving-epilepsy-diagnosis-with-a-wearable-device

87 Hale, C. (2018). Cochlear invests in Nyxoah's sleep apnea nerve implant in €15M round, Fierce Biotech. Available from: https://www.fiercebiotech.com/medtech/cochlear-invests-nyxoah-s-sleep-apnea-nerve-implant-eu15m-round

88 University of Melbourne. Improving epilepsy diagnosis with a wearable device. Available from: https://research.unimelb.edu.au/work-with-us/case-studies/improving-epilepsy-diagnosis-with-a-wearable-device

Dulux

Key insights: Dulux's collaboration with Siemens and their adoption of commercially available software enabled Dulux to create new market opportunities and maintain its market leadership.

Dulux Australia, in collaboration with Siemens, applied advanced manufacturing principles in developing an extremely high-standard batch control process at their state-of-the-art Merrifield paint factory, drawing upon pharmaceutical manufacturing techniques, and focused on end-to-end digitisation.

Dulux faced the challenge of needing to offer its market both small and large quantities of paint economically, whilst further raising its high quality standards.[89] Dulux sought to address this and to improve its responsiveness to latest trends, create new market opportunities, and remain a leader in paint manufacturing by investing $165 million in building the largest automated paint manufacturing facility in Australia and New Zealand, located in Merrifield, Victoria.[90] By building two plants under one roof – one for small batches and one for high volume paints – Dulux was successfully able to meet its challenges and implement a system that brought together all chemical plant processes within a single, highly-integrated control system.[91]

The implementation and successful operational launch of the plant was a result of close collaboration between Dulux and several industry partners.

Siemens was the Main Automation and Electrical Vendor, acting not only as Dulux's technology supplier but also its development partner.[92] Siemens enabled the use of advanced manufacturing techniques, such as the implementation of software that historically had only been used in the pharmaceutical industry.[93] CET Group acted as the chosen process and mechanical consultant.[94] Dromont provided a significant proportion of the process equipment, collaborating with DuluxGroup to achieve a fully automated manufacturing process environment. Mescada, as Siemens' solution partner for the project, was critical in digitalising the entire production process.[95]

The plant has created 70 new jobs in advanced manufacturing. With half the employees having no previous manufacturing experience and none having any paint manufacturing experience, a special training program, enabled by the sophisticated digital operating systems, was deployed to skill employees to operate in a fully automated end-to-end environment.

This investment offered significant manufacturing flexibility to Dulux, making it possible to produce a special order for one pallet of paint.[96] Dulux estimates that for small batches, the end-to-end manufacturing process is eight times faster than previously possible. Manual interventions were almost eliminated, allowing repeatability and pinpoint accuracy. The high degree of automation has also significantly reduced operator exposure to hazards, markedly improving worker safety.[97] More generally, the plant helped build local capability and infrastructure by challenging Australian project partners to make state-of-the-art deliveries and by upskilling workers in an advanced factory environment.

89 Siemens (2018). Batch size of one pallet: Any color desired. Available from: https://new.siemens.com/global/en/company/stories/industry/any-color-desired.html

90 PJM Engineering Services. Dulux Merrifield. Available from: https://pjmengineering.com/projects/dulux-merrifield; Siemens (2018). Batch size of one pallet: Any color desired. Available from: https://new.siemens.com/global/en/company/stories/industry/any-color-desired.html

91 Siemens. Customised chemical production made fast and easy. Available from: https://assets.new.siemens.com/siemens/assets/public.1559854843.aaa5d30b-67a0-4f25-8815-012e9091f989.customised-production-made-fast-easy.pdf

92 Siemens (2018). Batch size of one pallet: Any color desired. Available from: https://new.siemens.com/global/en/company/stories/industry/any-color-desired.html

93 Ibid.

94 CET Group. Dulux Merrifield. Available from: https://www.cetgroup.com.au/portfolio_page/dulux-merrifield/

95 CHEManager. "Our goal is to remain the market leader in paint production". Available from: https://www.chemanager-online.com/en/products/our-goal-remain-market-leader-paint-production

96 Siemens. Customised chemical production made fast and easy. Available from: https://assets.new.siemens.com/siemens/assets/public.1559854843.aaa5d30b-67a0-4f25-8815-012e9091f989.customised-production-made-fast-easy.pdf

97 FoodMach. Dulux Industry 4.0 Factory. Available from: https://s3-ap-southeast-2.amazonaws.com/foodmachcomau/foodmach_duluxcasestudy.pdf

Examples of collaboration models from countries with strong science and technology innovation systems

In consultations, stakeholders also discussed several countries (namely, Canada, the UK, the US, and Israel) that are globally strong on statistical indicators for science and technology commercialisation. These countries provide useful examples of collaboration models that are not readily common in Australia and that might help shape future planning activities in Australia:

Canada

- **Innovation assistance program for small and medium-sized businesses:** Recognising the importance of innovation in driving small and medium-sized business growth, Canada provides support to businesses through the National Research Council of Canada Industrial Research Assistance Program (NRC IRAP). The program offers financial assistance, advisory services, and connections to industry and R&D expertise to help small and medium-sized businesses increase their innovation capacity and commercialise ideas. [98] In terms of financial assistance, the NRC IRAP provides funding of up to $10 million for R&D projects at various stages of the innovation cycle.[99] It also offers technical and business advice, referrals, and other commercialisation services through industrial technology advisors;[100] connects domestic companies with funding, advisory, export, and innovation services through a network of regional, national, and international partners;[101] and provides financial support to companies to offset the costs of hiring young graduates that contribute to innovation activities.[102]
- **Financial support for innovation intermediaries:** In recognition of the role innovation intermediaries, such as for-profit business accelerators and not-for-profit business incubators, play in driving innovation and growth, the Canada Accelerator and Incubator Program (CAIP) was established.[103] The CAIP was a CAD 100 million non-repayable contribution program from 2014 to 2019, with the aim of establishing a critical mass of Canadian incubators and accelerators that could develop high-growth companies with promising early-stage innovations.[104] Based on the available data, the CAIP has enabled funded intermediaries to reach a larger number of companies, as well as enhance their capabilities, enabling them to work with more mature companies, rather than only smaller, early-stage ones.[105] Further, those companies that did experience high revenue/equity growth believed that incubator/accelerator assistance was an important factor in helping them achieving this growth.

98 National Research Council Canada (2019). About the NRC Industrial Research Assistance Program, Government of Canada. Available from: https://nrc.canada.ca/en/support-technology-innovation/about-nrc-industrial-research-assistance-program

99 National Research Council Canada (2019). Financial support for technology innovation through NRC IRAP, Government of Canada. Available from: https://nrc.canada.ca/en/support-technology-innovation/financial-support-technology-innovation-through-nrc-irap

100 National Research Council Canada (2019). NRC IRAP advisory services, Government of Canada. Available from: https://nrc.canada.ca/en/support-technology-innovation/nrc-irap-advisory-services

101 National Research Council Canada (2019). NRC IRAP international collaboration, Government of Canada. Available from: https://nrc.canada.ca/en/support-technology-innovation/nrc-irap-international-collaboration

102 National Research Council Canada (2020). NRC IRAP funding to hire young graduates, Government of Canada. Available from: https://nrc.canada.ca/en/support-technology-innovation/nrc-irap-funding-hire-young-graduates

103 National Research Council Canada (2019). Evaluation of the Canada Accelerator and Incubator Program (CAIP), Government of Canada. Available from: https://nrc.canada.ca/en/corporate/planning-reporting/evaluation-canada-accelerator-incubator-program-caip-0

104 Ibid.

105 Ibid.

The United Kingdom

- **Inter-sectoral mobility of researchers:** The UK has implemented programs to promote mobility between academia and other sectors. This is intended to generate more effective interaction between research, education, industry, and commercial innovations.[106] For example, the UKRI (UK Research and Innovation) and the Wellcome Trust fund training programmes offer recipients a wide range of development opportunities, including collaboration with non-academic partners, to prepare researchers for future careers in industry and elsewhere.
- **Challenge-based programs:** The UK has introduced challenge-based programs intended to solve specific national and global scale problems.[107] By linking research activity with the specific problem-solving goals early in the process, these programs can promote science and technology outputs that are more fit-for-purpose for the end-user than research-led programs that might not directly meet a market need. The Newton Fund was created in 2014 to fund collaborations on global challenges between academics and innovators in the United Kingdom and developing countries. More recently, the United Kingdom's Industrial Strategy Challenge Fund aims to target four health-related challenges. These include inventing new ways to detect and prevent disease development, and the "healthy ageing challenge", which asks industry and researchers to develop products and services to help people remain independent, productive, active, and socially connected for longer.

The United States

- **Public-private partnerships (PPPs):** These partnerships can combine private sector expertise and efficiencies with public sector risk-sharing, incentives, and resource access to deliver beneficial public outcomes more effectively. PPPs, often involving several companies, played central roles in accelerating COVID-19 vaccine rollout in the US.[108] Through Operation Warp Speed, the US had allocated more than USD 11 billion by October 2020 among more than 40 companies to fund the development of vaccines, diagnostics, therapeutics and other rapidly deployable capabilities. Similarly, the National Institutes of Health ACTIV is a PPP intended to coordinate research for prioritising and accelerating development of the most promising treatments and vaccines.
- **Bilateral innovation focused activities**. The US is also involved in a diverse range of bilateral science and technology funds with other countries, which are intended to share scientific priorities and ensure joint research activities that align with US policy interests.[109] Examples include the US-Israel Binational Science Foundation, the US-Egypt Science and Technology Joint Fund, the Indo-US Science and Technology Forum, and the US-Pakistan Science and Technology Cooperation Program.

106 OECD (2021). OECD Science, Technology and Innovation Outlook 2021: Times of Crisis and Opportunity. Available from: https://www.oecd-ilibrary.org/science-and-technology/oecd-science-technology-and-innovation-outlook-2021_75f79015-en

107 Ibid.

108 Ibid.

109 U.S. Department of State. Key Topics: Office of Science and Technology Cooperation. Available from: https://www.state.gov/key-topics-office-of-science-and-technology-cooperation/

Israel

- **Government-supported R&D collaboration:** The Israeli Government is involved in supporting collaboration between multinational companies and start-ups by providing an effective and supportive platform for them to connect and build partnerships. Through the Global Enterprise R&D Collaboration Program, the Israel Innovation Authority and the multinational company commit to equally invest in pre-selected R&D projects, conducted jointly by the multinational and a start-up.[110] Multinationals can invest funding in the joint project and/or provide in-kind services that can take the form of resources or facilities, such as technical guidance, personnel, equipment, and use of labs, in addition to cash funding.
- **Formal university-industry collaboration arrangements:** These collaborations can benefit academics by offering them the opportunity to access new skills, data, or equipment and to create tangible impacts from their research. They can help companies develop new techniques or technologies, de-risk research investments, and extend their technical capabilities. Technion, a science and technology research university based in Haifa has a strong mechanism for engaging entrepreneurs, with every student enrolled having to take a mandatory minor in entrepreneurship.[111] Similarly, at Hebrew University, researchers are strongly encouraged to engage with industry and liaise with professionals on real-life challenges to solve unmet market needs. Products based on the university's technology transfer developments have generated more than USD 2 billion in annual sales.[112]

Practical collaboration considerations for companies:[113]	• Does the company have an explicit framework that helps it to determine which collaborators to use? • Is the framework regularly reviewed to determine if the company's collaboration approach is still fit-for-purpose? • Are there areas where there could be greater sharing of funding, resources, and risk?
Other collaboration considerations:	• Are factors such as research translation and commercialisation objectives and attitudes relating to IP assessed when selecting innovation partners? • Is there an opportunity to leverage government support to solve industry wide challenges?

110 Israel Innovation Authority. R&D Collaboration with Multinational Corporations Program (MNC). Available from: https://innovationisrael.org.il/en/program/rd-collaboration-multinational-corporations-program-mnc

111 Rutter, S. (2015). Israel provides lessons in linking education and innovation, University of Technology Sydney. Available from: https://www.uts.edu.au/about/uts-business-school/news/israel-provides-lessons-linking-education-and-innovation

112 Ibid.

113 Many of these considerations are based on select findings from CSIRO's Unlocking Australia's resource potential report.

3.2 Long term strategy and targeted investment

The BCA members discussed the importance of having an explicit innovation strategy that supports the objectives and business model set out in the business strategy. They also noted that this innovation strategy should be owned and supported by the leadership team and board and clearly communicated across the company. Several BCA members articulated their approach to prioritising their innovation areas, including where they plan to be market leaders and where they plan to be fast followers or even late adopters. Similarly, many members articulated how they make innovation investments and how they plan their innovation investments over time. They also use horizon scanning to understand long-term trends, business cases to evaluate objectives, risks and rewards of prospective innovation investments, and monitoring and evaluation methods for measuring the impact of investments.

During the consultations, the BCA members acknowledged that there has been universal support around hydrogen energy technology. The emerging hydrogen industry is an example of where Australia has a clear national strategy and roadmap to guide industry development and targeted government co-investment is enabling projects to achieve enough scale to make medium- to long-term commercialisation economically viable.

Targeted co-investment in Australia's hydrogen sector

Australia has successfully moved from a national hydrogen industry strategy and CSIRO co-developed hydrogen roadmap to federal and state-level funding commitments; industry co-investments; and large-scale feasibility, demonstration and pilot projects across the country with plans to reach market in upcoming years.[114]

Australia has gained international attention in its hydrogen efforts and is well-positioned to begin securing commercial outcomes as projects mature. From 2015 to 2019, the federal government committed over $146 million to hydrogen projects along the supply chain.[115] This industry activity spans across all states and territories besides the Northern Territory.[116] Of these projects:

- 42 hydrogen projects now under development in Australia are led by BCA industry players such as APA Group, ATCO Australia, BHP, Fortescue Metals Group, Incitec Pivot, Origin Energy, and Woodside Energy.[117]
- 9 hydrogen projects currently under construction involve AGL Energy, APA Group, ATCO Australia, and Fortescue Metals Group.[118]
- 4 hydrogen projects in operation involve AGL Energy and ATCO Australia.[119]

114 CSIRO (2018). National Hydrogen Roadmap. Available from: https://www.csiro.au/en/work-with-us/services/consultancy-strategic-advice-services/CSIRO-futures/Futures-reports/Hydrogen-Roadmap; CSIRO. HyResource: Industry. Available from: https://research.csiro.au/hyresource/projects/facilities/

115 COAG Energy Council Hydrogen Working Group (2019). Australia's National Hydrogen Strategy, Canberra. Available from: https://www.industry.gov.au/sites/default/files/2019-11/australias-national-hydrogen-strategy.pdf

116 CSIRO. HyResource: Industry. Available from: https://research.csiro.au/hyresource/projects/facilities/

117 Ibid.

118 Ibid.

119 Ibid.

CASE STUDIES

The following case studies illustrate how BCA members are leveraging long term strategies and making targeted investments in innovation projects to gain competitive advantage, access new markets and enjoy growth and efficiency benefits.

Incitec Pivot

Key insight: Incitec Pivot successfully pursued its strategy to be a global leader in explosives for volcanic environments through its targeted investments in partnerships with Newcrest Gold and the University of Sydney.

Responding to the challenge posed by the volcanic environment surrounding the Lihir Mine in Papua New Guinea, Incitec Pivot collaborated with Australian company Newcrest Gold and University of Sydney researchers to develop and produce explosives suited for such environments. In their consultation, Incitec Pivot noted that research by experts from the University of Sydney led to world-leading knowledge on how conventional explosives behave in relation to temperature and pyritic materials, which then enabled Incitec Pivot to apply the research to solve this particular industry challenge. This strategic investment helped solve problems at the Lihir mine that significantly increased its value and provided Incitec Pivot with a competitive advantage for explosives in volcanic environments.

Coles

Key insight: Coles successfully pursued its strategy to digitally transform its business model and enjoy growth and efficiency benefits through its targeted investment in new technology solutions.

Coles has focused on collaborating with several providers on newly available technology solutions to digitally transform its business model and unlock new growth and efficiency opportunities. This includes partnering with Ocado to deliver world-leading order fulfilment for Coles Online with the construction of two automated Customer Fulfilment Centres,[120] as well as selecting international automation experts WITRON to build two automated distribution centres to modernise their supply chain.[121] Coles noted in their consultation that they also moved to an entirely online recruitment process during COVID-19 that enabled them to recruit thousands of people from hundreds of thousands of applications in a matter of weeks. These collaborative partnerships and pandemic-induced digital transformations have allowed Coles to innovate in the face of uncertainty and improve its resilience to external shocks.

120 Coles Group (2019). Coles enters partnership with Ocado. Available from: https://www.colesgroup.com.au/media-releases/?page=coles-enters-partnership-with-ocado

121 WITRON (2019). Why Coles decided in favour of WITRON. Available from: https://www.witron.de/en/news-detail/article/warum-sich-coles-fuer-witron-entschieden-hat.html

Decarbonisation strategies

Key insight: Wesfarmers is successfully pursuing its strategy to decarbonise its operations through targeted investments in energy efficiency technologies. Similarly, Microsoft is decarbonising its supply chain through targeted investments in carbon credits in the agriculture sector.

Wesfarmers has signalled its commitment to decarbonise its operations, with its retail divisions aspiring towards net zero emissions by 2030 and its chemicals, energy, fertilisers and Coregas divisions aspiring towards net zero by 2050.[122] The strategy to reduce the emissions of the retail division involved collaborations with several providers offering off-the-shelf technologies including LED lighting, energy management systems, and the widespread rollout of solar panels and battery installations.[123]

In 2020, Microsoft committed to being carbon negative by 2030 and has been seeking collaborative partnerships with carbon credit providers, including in Australia.[124] For example, Microsoft has partnered with New South Wales beef operation Wilmot Cattle Co to purchase approximately $500,000 worth of carbon credits.[125] Microsoft also collaborated with Regen Network, a blockchain start-up focused on ecological data and built on the Cosmos blockchain, where Microsoft purchased carbon credits that measure soil sequestration as well as animal welfare, soil health and general ecosystem health through remote sensing technology.[126] In engaging with these solution providers, Microsoft leveraged their internal and external data infrastructure and blockchain technology expertise in helping them meet their net zero emission target.

For Wesfarmers, their activities are meeting their shareholder expectations related to emission reductions and their hopes to eventually save on energy costs. For Microsoft, not only do these investments help them meet their net zero commitment, they help position the Australian agriculture industry as part of the climate change solution on an international scale.[127]

122 Wesfarmers (2020). Climate Action: on the path to net zero. Available from: https://www.wesfarmers.com.au/sustainability/our-stories/climate-action-on-the-path-to-net-zero

123 Wesfarmers (2020). Officeworks: Reducing our carbon emissions. Available from: https://www.wesfarmers.com.au/sustainability/our-businesses/officeworks/reducing-our-carbon-emissions; Powell, D. (2020). Woolworths pledges to cut emissions as investor pressure mounts, The Sydney Morning Herald. Available from: https://www.smh.com.au/business/companies/woolworths-gets-serious-on-climate-change-as-investor-pressure-mounts-20200924-p55yrl.html

124 Smith, B. (2020). Microsoft will be carbon negative by 2030, Microsoft. Available from: https://blogs.microsoft.com/blog/2020/01/16/microsoft-will-be-carbon-negative-by-2030/

125 Beef Central (2021). Aus cattle company makes global carbon credit sale to Microsoft. Available from: https://www.beefcentral.com/news/aus-cattle-company-makes-global-carbon-credit-sale-to-microsoft/

126 Thomson, G. (2021). Microsoft uses blockchain technology to purchase soil carbon credits in Australia, Cointelegraph. Available from: https://cointelegraph.com/news/microsoft-uses-blockchain-technology-to-purchase-soil-carbon-credits-in-australia

127 Goodwin, S. (2021). Microsoft buys carbon credits from NSW cattle operation, Farm Weekly. Available from: https://www.farmweekly.com.au/story/7105542/microsoft-buys-carbon-credits-from-nsw-cattle-operation/?cs=5151

FutureFeed

Key insight: Woolworths and GrainCorp, along with other industry partners, have co-invested in the company set to commercialise a highly innovative feed ingredient developed by CSIRO scientists, with the potential to bring significant domestic and global benefits to beef and dairy cattle producers, as well as reduce a major source of greenhouse gases.

FutureFeed is a CSIRO-developed, cost-effective seaweed supplement that can reduce the production of methane from beef and dairy cattle by more than 80% at low inclusion rates.[128] In 2020, CSIRO established the FutureFeed company to commercialise the technology, with co-investment support from Woolworths, GrainCorp, Harvest Road, and AGP Sustainable Real Assets/Sparklabs Cultiv8 Joint Venture.[129]

In addition to the significant reduction in methane emissions from livestock, FutureFeed also has a potential economic benefit to producers with studies suggesting the ingredient improves feed efficiency conversion and average daily weight gain through the conversion of energy otherwise lost in methane emissions. It has been estimated that if 10% of global ruminant producers adopted FutureFeed, it would have the same climate impact as removing 50 million cars, and potential increases in livestock productivity could create enough food to feed an additional 23 million people.[130] In recognition of its potential impact and contribution to sustainable and resilient food systems, the FutureFeed company has been awarded the USD 1 million Food Planet Prize, the largest monetary reward in the global food arena.[131]

Through co-investment support from companies such as Woolworths and GrainCorp, the FutureFeed company is working to build an entire industry around the technology by licensing seaweed growers, investing in further R&D, quality assurance, certification, marketing, and carbon credit methodology.[132] FutureFeed expects to see initial commercial volumes for early adopters of the supplement supplied into the domestic beef market by mid-2021, with international markets to follow.[133]

128 CSIRO (2021). FutureFeed. Available from: https://www.csiro.au/en/research/animals/livestock/futurefeed

129 CSIRO (2020). Million-dollar Food Planet Prize awarded to CSIRO innovation. Available from: https://www.csiro.au/en/news/news-releases/2020/million-dollar-food-planet-prize-awarded-to-csiro-innovation

130 CSIRO (2021). FutureFeed. Available from: https://www.csiro.au/en/research/animals/livestock/futurefeed

131 CSIRO (2020). Million-dollar Food Planet Prize awarded to CSIRO innovation. https://www.csiro.au/en/news/news-releases/2020/million-dollar-food-planet-prize-awarded-to-csiro-innovation

132 FutureFeed. Our Partners. Available from: https://www.future-feed.com/our-partners

133 CSIRO (2020). New company puts foot on the gas to reduce cows' methane. Available from: https://www.csiro.au/en/news/news-releases/2020/new-company-puts-foot-on-the-gas-to-reduce-cows-methane

Practical strategy considerations for companies:	• Does the company have an explicit innovation strategy? • Does the innovation strategy support the objectives and business model set out in the business strategy? • Is the company's innovation strategy aligned to a sector-wide or national strategy?
Other strategy considerations:	• Is the innovation strategy owned and supported by the leadership team and board and clearly communicated across the company? • Has the company distinguished between the areas where it will lead/fast follow versus those areas where it will be a late adopter? • For each area in the innovation portfolio, is there a clear business case that evaluates objectives, risks, and rewards? • Is there an understanding of the research translation and commercialisation activities needed? • Is there an understanding of the commercial, regulatory, environmental, and social factors that may support or hinder the progression of these innovations? • What internal and/or external sources are used to identify potential market disruptions and/or opportunities? • Does the company have a clear understanding of key players in the market and their innovation priorities?
Practical investment considerations for companies:	• Is there an agreed upon investment mix between early stage, emerging and commercially available innovations? • Does the investment mix align with the business strategy? • Does the company have a formal process for monitoring and evaluating innovation investments?
Other investment considerations:	• Does the company take a diversified portfolio view of innovation investments that balances low risk innovation investments alongside medium risk and higher risk projects? • Does the company have methods for measuring ROI that can appropriately account for the uncertainty of breakthrough and disruptive innovation types? • How well does the company understand the full costs of innovation and benefits based on different investment timings? • For each project in the innovation portfolio, is there an explicit understanding of the value of owning IP versus acquiring IP through sharing or licensing? • Does the company's investment decision-making framework support the assessment of innovation projects at various stages of development, including go/no-go decision gates?

3.3 Culture, risk sharing and alignment of incentives

The BCA members who were consulted emphasised the significance the culture, risk allocation and incentives alignment have on the success (or failure) of innovation activities. Several BCA members noted that innovation 'starts at the top' with senior executives and the boards of successful innovating companies (which are often the most enduring part of companies) championing innovation, embracing a 'growth through innovation' culture,[134] and actively working to improve their company's capacity to innovate.

Most of the stakeholders discussed the challenges of allocating risk and aligning incentives both within companies and with external partners. It was understood that companies that can openly address and negotiate the allocation of risks and IP, as well as the alignment of incentives, are more likely to see their projects progress to commercial outputs. Stakeholders have also noted the importance of companies and research organisations developing a shared language to foster mutual interest, build potential partnerships, and drive collaboration.

134 Green, R., Howard, J. H, (2015). Australia's Innovation Future: A Report on the Structure and Performance of Australia's National Innovation System. Available from: https://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Economics/Innovation_System/~/media/Committees/economics_ctte/Innovation_System/Final_Report/e05.pdfhttps://www.aph.gov.au/Parliamentary_Business/Committees/Senate/Economics/Innovation_System/~/media/Committees/economics_ctte/Innovation_System/Final_Report/e05.pdf

CASE STUDIES

The following case studies illustrate how BCA members are embracing a 'growth through innovation' culture, aligning incentives, and openly sharing risk and IP with their innovation partners to successfully drive the development and adoption of new technologies.

Woodside

Key insight: Building on a prior successful relationship, an ongoing innovation culture and careful negotiation of IP sharing have contributed to the success of the Woodside Monash Energy Partnership.

The Woodside Monash Energy Partnership was launched in July 2019 as a multi-year research program to drive Australia's next generation of sustainable energy technologies and carbon solutions.[135] Woodside is jointly investing $40 million over seven years to support six cross-disciplinary and cross-organisational projects in new energy technologies; carbon capture, conversion and utilisation; and energy leadership.[136] A core team of three Woodside leaders and six Monash University researchers are leading the projects with support from other Woodside and Monash staff.[137] The partnership builds on a prior successful Woodside-Monash relationship of the 2016 Woodside FutureLab at Monash.[138]

In their consultation, Woodside noted that the geographical proximity of Monash University Clayton to a local innovation ecosystem, including other local research organisations such as CSIRO Clayton, was a drawcard for the partnership as the ecosystem enables deliberate and accidental IP creation that is key to an ongoing innovation culture. The partnership is set up so that Monash University owns the IP created, except for a few strategic areas where Woodside retains rights, with this arrangement ensuring both parties' needs are met. Through strong ties with Monash start-ups and students, Woodside also enjoys early access to promising ideas and talent.[139]

Telstra

Key insight: A shared culture of innovation, risk sharing, and incentives alignment enabled Telstra to partner with Microsoft and many others to use Australia as a testing ground for telecommunications technologies and accelerate technology development and adoption.

By collaborating with multinational corporations, Telstra is accelerating technology development and uptake. This is exemplified by their deep collaboration with industry partners based on a shared mindset around the mutual benefits of technology development and acceleration, as well as a willingness to share the risks of technology adoption.

Partnerships with Qualcomm and Ericsson are setting industry standards in 5G download speeds.[140] Telstra has partnered with Amazon Web Services to bring cloud services to Australian enterprises.[141] With Microsoft Azure, Telstra is leveraging the Telstra Data Hub and developing solutions in asset tracking and supply chain management.[142] Telstra is also collaborating with Microsoft and Amazon Web Services to deliver edge computing-enabled highly reliable and low latency use cases, and plans to repurpose 650 Australian sites for edge computing.[143] Not only do these partnerships strengthen Telstra's position as an industry leader in Australian telecommunications, it also invites more global companies to use Australia as a testing ground for telecommunication technologies and helps accelerate national-level technology development.

135 Monash University. Woodside Monash Energy Partnership. Available from: https://www.monash.edu/woodside/energy-partnership

136 Monash University, Woodside (2019). Woodside Futurelab and Energy Partnership at Monash University: Annual Report 2019. Available from: https://files.woodside/docs/default-source/innovation/woodside-futurelab-monash-annual-report-2019.pdf?sfvrsn=2c79951e_6

137 Monash University. Woodside Monash Energy Partnership. Available from: https://www.monash.edu/woodside/energy-partnership

138 Ibid.

139 Monash University, Woodside (2019). Woodside Futurelab and Energy Partnership at Monash University: Annual Report 2019. Available from: https://files.woodside/docs/default-source/innovation/woodside-futurelab-monash-annual-report-2019.pdf?sfvrsn=2c79951e_6

140 ChannelLife (2021). New 5G download speed record set on a commercial network. Available from: https://channellife.com.au/story/new-5g-download-speed-record-set-on-a-commercial-network

141 Tan, A. (2021). AWS and Telstra team up on 5G, ComputerWeekly.com. Available from: https://www.computerweekly.com/news/252495837/AWS-and-Telstra-team-up-on-5G

142 Chanthadavong, A. (2020). Microsoft and Telstra to partner on cloud, IoT, and digital twins, ZDNet. Available from: https://www.zdnet.com/article/microsoft-and-telstra-to-partner-on-cloud-iot-and-digital-twins/

143 Mehta, A. (2020). Edge Computing in 2021 and how Telstra can help, LinkedIn. Available from: https://www.linkedin.com/pulse/edge-computing-2021-how-telstra-can-help-amit-mehta/

Practical culture considerations for companies:	• Are senior executives in the company seen as champions for innovation? • Does the company have innovation champions at all levels who actively seek to improve the company's capacity to innovate? • Does the company clearly and openly articulate its cultural expectations with both its internal and external innovation-related stakeholders?
Other culture considerations:	• Does the company have a culture that encourages continuous debate, inquiry, and sense checking of new ideas, including 'blue sky' research topics? • Does the company's culture enable it to openly negotiate risk and IP sharing arrangements with its external innovation partners? • Does the company's culture foster the rapid adoption of the best ideas and firm-specific solutions from both Australian and international sources? • Does the company's leadership draw on learnings from, or actively invest in, senior members with overseas/start-up experience?
Practical risk and incentives considerations for companies:	• Is there a well-articulated attitude to risk awareness and management that enables the generation and exploration of ideas with a variety of risk profiles? • Are lessons from success and failures routinely identified, shared, discussed, and used to improve future outcomes? • Is innovation effort consistently recognised and appropriately rewarded?

3.4 Skills, talent, and capability building

The consultations also highlighted the importance of skills, talent, and capability in undertaking effective collaboration for innovation. One member discussed the "talent pipeline" and how drawing on international industry and academic research experience was necessary to build a critical mass so that strategic and deliberate collaboration opportunities are more likely. Increasing the occurrence of industry related PhDs is one way successfully innovating countries increase industry participation in commercialisation activities by researchers.[144]

While one approach for companies to address this is through greater investment in 'hard skills', such as in STEM talent and capabilities aligned to technological transformation and innovation adoption, another aspect of this also relates to 'soft skills' that foster business-research engagement. Stakeholders consulted believe this includes upskilling the broader workforce and strengthening its capacity to engage with the research sector, finding areas of mutual interest with external partners, and having productive conversations with those with deep technical expertise.

144 Riley, J. (2018). Industrial PhD's in the real world, InnovationAus. Available from: https://www.innovationaus.com/industrial-phds-in-the-real-world/

The importance of building digital skills, talents, and capabilities

Aside from research talent, BCA members also noted the greater need for Australian companies to develop their digital capabilities such as data management and analytics, and to sustain the momentum of accelerated digital adoption seen through COVID-19. Similarly, as noted in BCA consultations, customers are increasingly expecting high-quality digital services and there is a growing emphasis on cybersecurity in sectors such as finance. Having an enterprise data strategy, for instance, enables companies to innovate from a position where they better understand their market position. Having skilled personnel that can build a data management and data analytics infrastructure in the company can also enable it to experiment and monitor innovations more effectively.

However, it is important to acknowledge that software development as a form of product/service innovation differs from more traditional areas of research translation and commercialisation in many ways, particularly in terms of the role of skills and talent. Based on information provided in consultations, software research translation and commercialisation activities often interweave product, service, and business model innovations, in a way its non-digital counterparts do not. As such, software-based companies often sidestep what is understood to be the traditional R&D process. Further, once the base infrastructure has been established, software development is primarily labour and coding skills/talent (e.g. in contrast to laboratory facilities, material inputs, capital equipment necessary for other types of research translation and commercialisation). The implication of this is that features, functionality, and core capabilities of software can be rapidly developed and altered in significantly shorter timeframes than more traditional commercialisation activities.

CASE STUDIES

The following case studies illustrate how BCA members are actively building skills and capability in Australia both in emerging research areas as well as broader digital capabilities for competitive advantage.

Australian quantum computing research

Key insight: Government, university and industry's co-investments and CSIRO's coordination activities are building Australia's quantum research workforce and infrastructure, and positioning Australia as a global player in quantum computing research.

Quantum computing enables an entirely new form of computation. CSIRO's *Quantum Roadmap*[145] was developed collaboratively with industry, research and government to support the coordination and growth of the Australian quantum ecosystem. Industry and government are now investing in quantum technologies. Most recently, the Australian Government announced a $111 million investment in Australia's quantum industry.[146]

Prior to this, the Silicon Quantum Computing company at University of New South Wales was launched in 2017 to bring together the research and expertise of over 40 Australian researchers, through over $83 million of funding from federal and state government, the university, and Commonwealth Bank of Australia and Telstra as industry partners.[147]

In parallel, Microsoft recently signed a multi-year partnership with the University of Sydney for quantum research[148] and IBM partnered with Adelaide-based Archer Materials to build a quantum computing qubit processor.[149] These companies are able to leverage Australia's world-leading quantum computing research talent, which gives its quantum computing ecosystem an international presence and provides the emerging industry with investment, direction, and global connectivity needed for successful future growth.[150]

145 CSIRO (2020). Growing Australia's Quantum Technology Industry.

146 Prime Minister of Australia (2021). Media Release: $111 million investment to back Australia's quantum technology future, Canberra. Available from: https://www.pm.gov.au/media/111-million-investment-back-australias-quantum-technology-future

147 Silicon Quantum Computing. Available from: http://sqc.com.au/

148 Reiner, V. (2017). Microsoft and University of Sydney forge quantum partnership, The University of Sydney. Available from: https://www.sydney.edu.au/news-opinion/news/2017/07/25/microsoft-and-university-of-sydney-forge-quantum-partnership.html

149 Tchetvertakov, G. (2020). Archer Materials teams up with IBM to develop net-gen quantum computing processor, Small Caps. Available from: https://smallcaps.com.au/archer-materials-ibm-develop-next-gen-quantum-computing-processor/

150 CSIRO (2020). Growing Australia's Quantum Technology Industry.

Google

Key insight: Google's partnership with Australian biotech Microba is helping to build Microba's cloud capabilities and data infrastructure for competitive advantage.

Google has partnered with Microba, an early-stage Australian biotech company establishing itself as a world leader in gut microbiome analysis, to help it more efficiently manage its data volumes and processing requirements by migrating to a public cloud service.[151] Microba selected Google Cloud as their desired cloud service and migration partner due to the availability and level of technical support and expertise from Google, as well as their cloud capabilities such as high throughput networking and Kubernetes.[152] This allowed Microba to invest more time into research, analysis, and product development while expanding their gut microbiome database seamlessly.

Google's investment in building their internal expertise in genomics data, as well as their extensive digital capabilities, have enabled them to partner with Microba to build the company's cloud capabilities and data infrastructure. This has provided Google with a competitive advantage in cloud services and migration for biotech companies in Australia and abroad dealing with genomics/biomedical data.[153]

In addition, Google Australia recently launched the Digital Future Initiative, a $1 billion investment in Australian infrastructure, research and partnerships that aims to strengthen local capabilities, support jobs and help build Australia's digital economy for the future. Through this initiative Google is expanding its Australian collaborations, including a research partnership with CSIRO to tackle Australia's greatest challenges through innovation.[154]

151 Google Cloud. Microba: Turning to Google Cloud ML and data infrastructure to help transform gut health. Available from: https://cloud.google.com/customers/microba/; Barbaschow, A. (2019). Aussie biotech Microba using AI to research gut microbiome, ZDNet. Available from: https://www.zdnet.com/article/aussie-biotech-microba-using-ai-to-research-gut-microbiome/

152 Microba and Google Cloud use innovation and AI to level up gut microbiome testing, PR Wire. Available from: https://prwire.com.au/print/microba-and-google-cloud-use-innovation-and-ai-to-level-up-gut-microbiome-testing-1

153 Google Cloud. Cloud Life Sciences. Available from: https://cloud.google.com/life-sciences#:~:text=Cloud%20Life%20Sciences%20(formerly%20Google,takes%20care%20of%20the%20rest.

154 Silva, M (2021). How we're helping build a strong digital future - for all Australians. Available from: https://blog.google/intl/en-au/company-news/outreach-initiatives/digital-future-initiative/

Practical skills and talent considerations for companies:	• Does the company have skilled personnel that are able to interface with research expertise and are actively building new relationships with external research groups? • Does the company have staff with business development, commercialisation, and entrepreneurial skills that can consider end-markets and commercialisation pathways from the outset? • Does the company have a talent pipeline that seeks to develop, attract, and retain talent (including recruiting for capability gaps)?
Other skills and talent considerations:	• Does the company deliberately construct teams with a mix of diverse technical and business skills, attributes, and experiences? • Does the company have the right skills to transform business objectives into the appropriate research translation and commercialisation project questions? • Does the company have the skills to identify and address technology/infrastructure investment barriers and gaps? • Does the company have the skills to identify and then effectively and efficiently engage with a range of potential external solution providers to address firm-specific needs and challenges?
Practical capability building considerations for companies:	• Does the company have a clear understanding of its internal strengths relative to the strengths of potential partners in the innovation ecosystem? • Is there a long-term advantage to the company of developing the skills and capabilities internally to build or improve core competency in a new or existing area? • Does the company have an enterprise data strategy and the necessary data management and analytics capabilities to interrogate its own business data and evaluate the impact of its off-the-shelf technology solutions?

4 Conclusion

The groundwork for a successful technology-enabled recovery is already present in Australia. By leveraging science and technology, companies will be well-positioned, coming out of the pandemic, for greater levels of productivity and profitability.

Significant barriers to commercialisation still exist in Australia, including low levels of collaboration; a lack of comprehensive innovation strategy and targeted investment; a risk-averse business culture and incentive misalignment between research partners and companies; and a talent and skills mismatch in the economy. However, Australian companies can take practical actions to overcome these barriers. Companies can achieve better commercial outputs from science and technology by harnessing enablers in greater levels of industry, research, and government collaboration; long term strategy and targeted investment; culture, risk sharing and incentives alignment; and in skills, talent, and capability building.

This report highlights many success stories from BCA members which demonstrate the practical actions that Australian companies can take to gain competitive advantage, build commercialisation competencies, drive technology development and adoption, and access new markets and growth opportunities. It is intended to inspire and instigate high-level discussions with corporate and government leaders in Australia on how to improve commercial outcomes from science and technology.

Although this report does not address every question in the realm of innovation and commercialisation, it illuminates practical, evidence-based, and implementable steps for companies. By adopting these steps, Australian companies can partner with domestic and international companies, governments, and research organisations such as universities and CSIRO, to bridge the commercialisation gap and unleash technology-led economic growth.

5 Appendix: Summary of considerations

Collaboration

Practical collaboration considerations for companies:	• Does the company have an explicit framework that helps it to determine which collaborators to use? • Is the framework regularly reviewed to determine if the company's collaboration approach is still fit-for-purpose? • Are there areas where there could be greater sharing of funding, resources, and risk?
Other collaboration considerations:	• Are factors such as research translation and commercialisation objectives and attitudes relating to IP assessed when selecting innovation partners? • Is there an opportunity to leverage government support to solve industry wide challenges?

Long term strategy and targeted investment

Practical strategy considerations for companies:	• Does the company have an explicit innovation strategy? • Does the innovation strategy support the objectives and business model set out in the business strategy? • Is the company's innovation strategy aligned to a sector-wide or national strategy?
Other strategy considerations:	• Is the innovation strategy owned and supported by the leadership team and board and clearly communicated across the company? • Has the company distinguished between the areas where it will lead/ fast follow versus those areas where it will be a late adopter? • For each area in the innovation portfolio, is there a clear business case that evaluates objectives, risks, and rewards? • Is there an understanding of the research translation and commercialisation activities needed? • Is there an understanding of the commercial, regulatory, environmental, and social factors that may support or hinder the progression of these innovations? • What internal and/or external sources are used to identify potential market disruptions and/or opportunities? • Does the company have a clear understanding of key players in the market and their innovation priorities?
Practical investment considerations for companies:	• Is there an agreed upon investment mix between early stage, emerging and commercially available innovations? • Does the investment mix align with the business strategy? • Does the company have a formal process for monitoring and evaluating innovation investments?
Other investment considerations:	• Does the company take a diversified portfolio view of innovation investments that balances low risk innovation investments alongside medium risk and higher risk projects? • Does the company have methods for measuring ROI that can appropriately account for the uncertainty of breakthrough and disruptive innovation types? • How well does the company understand the full costs of innovation and benefits based on different investment timings? • For each project in the innovation portfolio, is there an explicit understanding of the value of owning IP versus acquiring IP through sharing or licensing? • Does the company's investment decision-making framework support the assessment of innovation projects at various stages of development, including go/no-go decision gates?

Culture, risk sharing and incentives alignment

Practical culture considerations for companies:	• Are senior executives in the company seen as champions for innovation? • Does the company have innovation champions at all levels who actively seek to improve the company's capacity to innovate? • Does the company clearly and openly articulate its cultural expectations with both its internal and external innovation-related stakeholders?
Other culture considerations:	• Does the company have a culture that encourages continuous debate, inquiry, and sense checking of new ideas, including 'blue sky' research topics? • Does the company's culture enable it to openly negotiate risk and IP sharing arrangements with its external innovation partners? • Does the company's culture foster the rapid adoption of the best ideas and firm-specific solutions from both Australian and international sources? • Does the company's leadership draw on learnings from, or actively invest in, senior members with overseas/start-up experience?
Practical risk and incentives considerations for companies:	• Is there a well-articulated attitude to risk awareness and management that enables the generation and exploration of ideas with a variety of risk profiles? • Are lessons from success and failures routinely identified, shared, discussed, and used to improve future outcomes? • Is innovation effort consistently recognised and appropriately rewarded?

Skills, talent, and capability building

Practical skills and talent considerations for companies:	• Does the company have skilled personnel that are able to interface with research expertise and are actively building new relationships with external research groups? • Does the company have staff with business development, commercialisation, and entrepreneurial skills that can consider end-markets and commercialisation pathways from the outset? • Does the company have a talent pipeline that seeks to develop, attract, and retain talent (including recruiting for capability gaps)?
Other skills and talent considerations:	• Does the company deliberately construct teams with a mix of diverse technical and business skills, attributes, and experiences? • Does the company have the right skills to transform business objectives into the appropriate research translation and commercialisation project questions? • Does the company have the skills to identify and address technology/infrastructure investment barriers and gaps? • Does the company have the skills to identify and then effectively and efficiently engage with a range of potential external solution providers to address firm-specific needs and challenges?
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csiro.au

For further information
CSIRO Futures
Dr Katherine Wynn
+61 412 364 696
katherine.wynn@csiro.au
csiro.au/Showcase/CSIRO-Futures

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