ACTON INSTITUTE FOR POLICY RESEARCH AND INNOVATION

Australian innovation at the crossroads: The slump in national R&D since 2008—causes, consequences and prospects

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CONTENTS

LIST OF FIGURES

Preface

This Paper is a consolidation of four contributions to the @AuManufacturing.com project on Turbocharging the Australian Economy to 3% of GDP.

The project, initiated by Peter Roberts, involved contributions from 20 writers and is being published as an e-book titled *Towards 3%: Recharging the Australian economy*.

The onset of the global financial crisis (GFC) was the most pivotal factor influencing the economic landscape in 2008. The GFC had profound implications for economies worldwide, causing a sharp contraction in economic activity and a decline in business and consumer confidence. Australian businesses were not immune to these global pressures, and the subsequent economic uncertainty likely played a substantial role in the observed reduction in investment.

The Paper proposes five core policy initiatives that would strengthen Australian business R&D commitment and secure a path to knowledge-driven growth. This pathway will involve supporting and stimulating R&D in businesses that constitute the Industries of the Future and steer the economy away from reliance on the export of commodity materials. it almost goes without saying that Australia requires a National Business Research and Development Strategy and Action Plan.

The Prime Minister and the Minister for Industry and Science should orchestrate this through the Australian National Science and Technology Council. It should not be outsourced to an independent Review.

The development of the Strategy and Action Plan must involve rigorous analysis and testing of propositions not only in terms of their desirability but also in terms of their practicality and feasibility.

Many previous reports on lifting business investment have tended to use the "wisdom of the crowd" through extended consultations and relied less on the knowledge contained in previous reports, understanding why they have not had an impact and the input of national and business development experts.

The Paper concludes with a proposal to establish a National Research/Science Foundation, building on the models of Germany, Israel, Korea, and the USA. The Foundation would guide the development of a strategy to lift business R&D investment in a broader national R&D context and address its implementation across Australia's very complex system of public administration.

The problem: Australia's poor R&D performance

Australia currently spends 1.68% of GDP on research and development. This is well below the proportion of what are considered to be Australia's peer group nations (except Canada).

In November 2022, the Minister for Industry, Science and Resources announced a target of 3% of expenditure on R&D as a proportion of GDP[1]. We are a long way off that target, and since 2008 and the Global Financial Crisis (GFC), Australia has been falling further behind relative to what we consider our R&D investing peers.

Most of the countries used the GFC as a call to *step up* their investment in R&D, but Australia did not. The aspiration for countries to allocate 3% of their Gross Domestic Product (GDP) to Research and Development (R&D) expenditure is a widely recognised benchmark and policy goal

Why 3%?

The 3% objective is founded on the belief that a higher investment in R&D contributes significantly to economic growth, innovation, and overall competitiveness.

Several reasons support the pursuit of this 3% target:

- Innovation and Technological Advancement: Increased R&D spending fosters innovation, leading to the development of new technologies, products, and services. This, in turn, enhances a nation's competitiveness on the global stage.
- Economic Growth and Productivity: R&D investment is linked to economic growth and increased productivity. It fuels the development of cutting-edge technologies, which can have widespread applications across various industries, driving economic expansion.
- Job Creation: A thriving R&D sector generates employment opportunities. The development of new technologies and industries often requires skilled workers, contributing to job creation and economic development.
- Global Competitiveness: Nations with a robust R&D sector are better positioned to compete globally. The 3% target reflects a commitment to staying at the forefront of technological advancements, ensuring that a country remains competitive in the international arena.
- Quality of Research Output: Setting a specific percentage of GDP for R&D encourages countries to focus not only on the quantity but also on the quality of research. This can lead to more impactful discoveries and advancements.
- Scientific and Technological Leadership: Achieving the 3% goal is seen as a pathway to establishing leadership in science and technology. It enables countries to take the lead in critical areas, influencing global standards and developments.
- Addressing Societal Challenges: R&D investment is instrumental in solving pressing societal challenges, such as healthcare, climate change, and energy. The 3% target signals a commitment to leveraging research for the betterment of society.
- Knowledge-Based Economy: Emphasizing R&D expenditure aligns with the transition toward a knowledge-based economy. Countries investing in research and innovation are better positioned to adapt to rapid technological changes and capitalize on intellectual capital.
- Long-Term Economic Resilience: R&D is an investment in the future. Countries allocating 3% of GDP to research are better equipped to navigate economic uncertainties, as innovation becomes a driver of resilience and adaptability.

While the 3% target is widely acknowledged internationally, its achievement requires a comprehensive policy framework, collaboration between government, academia, and industry, and a conducive environment for research and innovation to flourish.

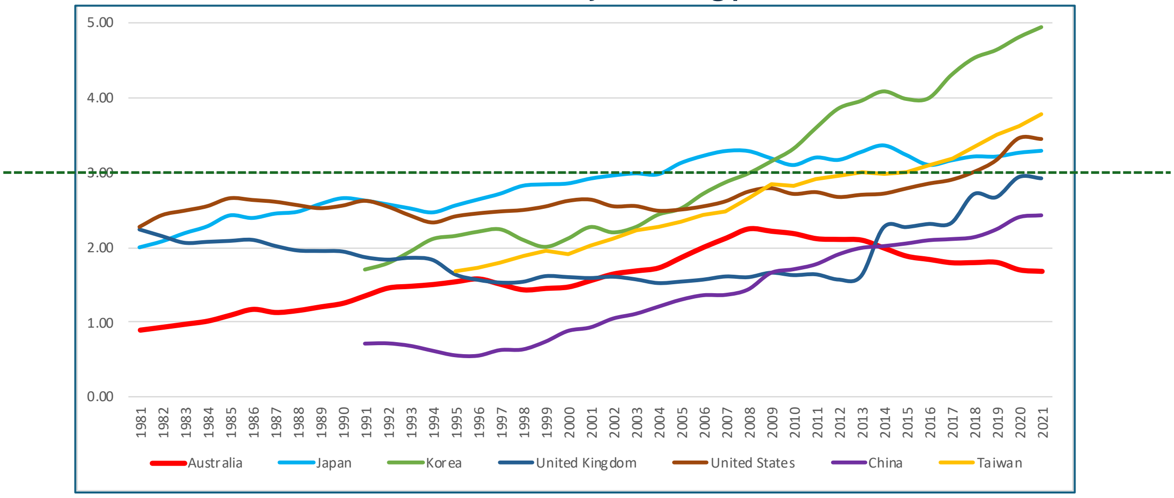
For Australia to make the 3% target more than a rhetorical aspiration, serious investments are required by the business and government sectors.

[1] The Hon Ed Husic MP, 2022. Speech at the UTS Vice-Chancellor's Innovation Showcase, 3 November 2022, University of Technology Sydney https://www.minister.industry.gov.au/ministers/husic/speeches/speech-uts-vice-chancellors-innovation-showcase

The statistics do not lie

In 1981, Australia spent 0.90% of its GDP on R&D—the lowest among its major trading partners (Japan, Korea, the UK, USA, China, and Taiwan). Forty years later, in 2021, the proportion is still the lowest, at 1.68%. Not only that, as shown in Figure 1, Australia (red line) is falling further behind in its commitment to R&D. The 3% "benchmark" is shown in Figure 1 for information.

Figure 1: Gross domestic spending on R&D as a proportion of GDP 1981-2021 (%): Australia's and its major trading partners



Source: OECD [Main Science and Technology Indicators (MSTI database)](), Accessed 9 Feb, 2024

Over the 40-year period, things looked good until 2008, when Australian R&D reached a peak of 2.24% of GDP (close to the OECD average of 2.28%). Then it collapsed.

Since 2008, the Australian economy has grown by exporting mineral and energy resources, which have paid for imports of manufactured products. These products are consumed by a growing population stimulated by high levels of immigration. Many of these resource companies had made substantial investments in R&D in Australia.

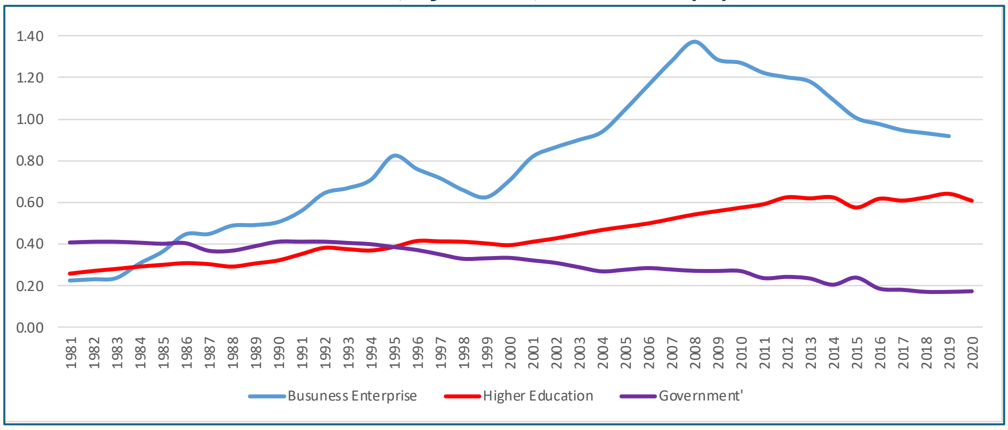
R&D undertaken by the resources sector is now being undertaken globally through the innovation sourcing strategies of global corporations like Woodside, Shell, and Rio Tinto (a UK corporation). These companies have also shifted their focus to sustainable energy technologies; very little of this is done in Australia.

The sectoral distribution of R&D expenditure

In Australia, as in most other countries, the business sector undertakes the largest proportion of R&D in GDP, but as shown in Figure 2, that proportion peaked in 2008—at 1.37%—and has since declined to 0.92% (recorded in 2019).

This collapse in business R&D, together with a trend decline in government expenditure on R&D since 1995, has been the major source of Australia's R&D problem. If it hadn't been for the growth in higher education expenditure R&D, which has trended upward since 2000, Australia's overall R&D performance would have been much worse.

Figure 2: Gross domestic spending on R&D as a proportion of GDP: Australia, by sector, 1981-2021 (%)



Source: OECD Main Science and Technology Indicators (MSTI database), Accessed 21 March 2024

The collapse in business R&D has occurred entirely in large companies[2]. Globally, within this large company cohort, business research and development investment is heavily concentrated in the motor vehicle, pharmaceuticals, and technology industries. Australia no longer has any global motor vehicle companies doing R&D in Australia, and only one global pharmaceutical company (CSL).

Technology companies with substantial product sales in Australia do little, if any, R&D in Australia. In 2018, Microsoft had a global 2018 R&D spend of $US14.75 billion), Intel ($US 13.10 billion), Apple ($11.58 billion), Oracle ($US6.09 billion), Cisco ($US6.06 billion), and IBM ($5.79 billion).

These and other large corporations outsource aspects of their R&D, and countries compete intensely for a slice of this investment. However, unlike other countries, Australian Commonwealth and State foreign direct investment strategies do not target R&D investment. The focus tends to be on "creating jobs"—any jobs. States tend to compete with each other rather than take a "one Australia" approach.

Global corporations have choices, and the availability of collaborative research infrastructure at higher education institutions and public research organisations are a major influence on those choices.

Growth in Higher Education Expenditure on R&D was sustained by strong policy interest in the sector—until 2013.

In 2003, the Education Minister (The Hon. Brendan Nelson) released the White Paper *Our Universities: Backing Australia's Future*. Initiatives such as the Howard Government's *Education Endowment Fund and* Gillard's *Higher Education Investment Fund (EIF)* sustained the upward trajectory until 2014 when it stalled. International student fees have largely financed the recovery from 2016.

It is disappointing that the proportion of Government expenditure on R&D has fallen from 0.41% of GDP in 1981 to 0.17% in 2020. This reflects the Commonwealth Government's failure to support its own research institutes and laboratories, including CSIRO, ANSTO, and DST, and State Governments failing to maintain support for their agricultural research institutes and laboratories.

[2] Jones. Brad, 2024. Financing SME Innovation in Australia – Challenges and Opportunities, Speech to the COSBOOA National Small Business Summit, Sydney, 4 April 2004. https://www.rba.gov.au/speeches/2024/sp-ag-2024-04-04.html

It is not hard to conclude that the Australian sectoral distribution of R&D is unsatisfactory. Australia's national R&D mix fundamentally differs from our trading partners, where business R&D is a more significant component of the national R&D profile.

In 2019, Australian higher education expenditures on R&D amounted to 37.1% of national research investment (compared to 24.8% in 2008), with business contributing 53.0% (62.8%) and government 9.9% (12.4%). On these metrics, higher education appears to be doing the "heavy lifting" in Australia's R&D commitment and, in many ways, setting the pace for national R&D investment priorities.

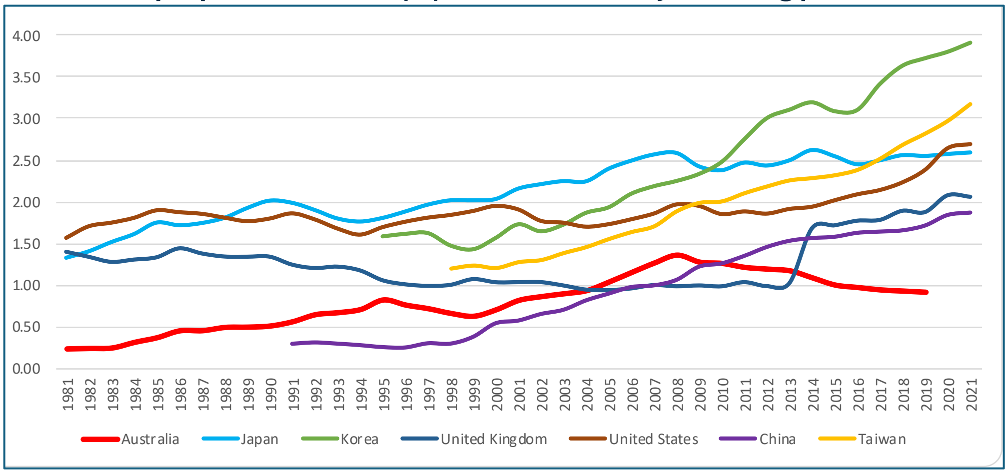
Higher education priorities are reflected in health and medical research investments, with 30% of publications in life sciences fields—biological, biomedical, clinical, and health sciences. This compares with an output of 19.2% in the Natural Sciences (Chemistry, Physics and Earth Sciences), 19.8% in Engineering and Information and Computing Sciences, and 18.5% in the HASS disciplines.

These investments may or may not reflect a national R&D strategy. Since we do not have one, we would not know.

Business Expenditure on R&D

Figure 3 shows Business Research and Development expenditures for Australia's major trading partners. In 1981, the Australian proportion was 0.23% of GDP and increased to 1.37% in 2008 (OECD average of 1.57%). But by 2019, it had fallen to 0.92%—half the OECD average of 1.84%.

Figure 3: Business Enterprise Expenditure on R&D (BERD) as a proportion of GDP (%)—Australia's major trading partners



Source: OECD [Main Science and Technology Indicators (MSTI database)](), Accessed 9 Feb, 2024

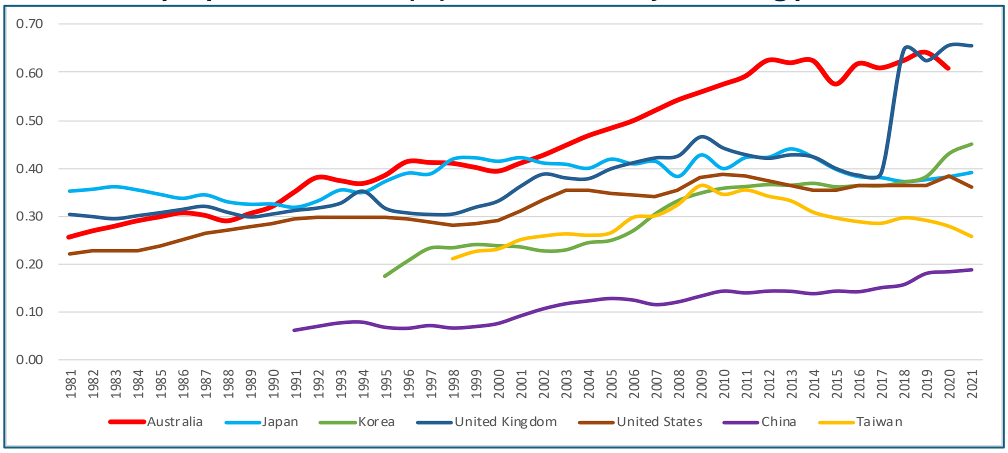
Figure 3 also demonstrates that most countries progressively increased their business R&D commitment after the GFC (2008).

Within the OECD dataset, the only other countries to record significant reductions in business expenditure on R&D post-GFC were Canada, Denmark, Finland, and Sweden. Several other EU countries increased their R&D commitment, including France, Ireland, Italy, and the Netherlands, possibly reflecting the impact of the EU Horizon program.

Higher education expenditure on R&D

Higher education research plays a significant role in the national R&D effort in Australia, Korea, and the UK. Figure 4 provides the proportion of higher education expenditure on R&D (HERD) in GDP Australia's major trading partners.

**Figure 4: Higher Education Expenditure on R&D (HERD)
as a proportion of GDP (%): Australia's major trading partners**



Source: OECD [Main Science and Technology Indicators (MSTI database)](), Accessed 9 Feb, 2024

The Australian proportion steadily increased from 0.23% in 1981 to 0.61% in 2019 (reaching 0.64% in 2018). The proportion in the UK reached 0.66 in 2019, having shot up rapidly since 2017 due to a change in collection methodology that added R&D that is both funded and performed by HE institutions, as in Australia.

ABS data shows that international postgraduate students undertake a substantial proportion of higher education R&D. The international student fee bonanza is not reflected in the appointment of permanent academic research staff. Causal and short-term project-funded appointments have carried a heavy workload.

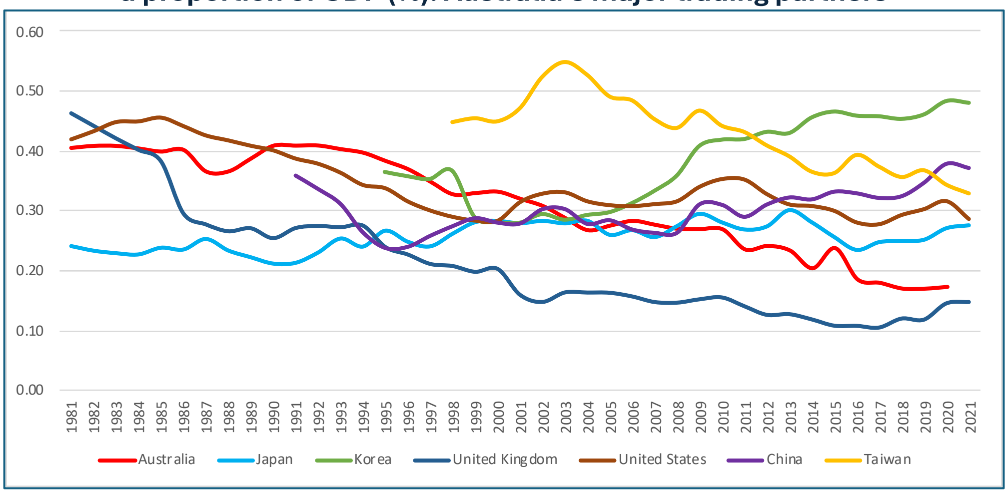
The Government's own expenditure on R&D

Government research facilities are essential institutions in a national R&D capability—working with businesses to commercialise and market R&D outcomes created in government organisations established to discover and explore new knowledge and take on a higher level of risk.

Government research institutions also perform important research contracting roles and participate in global technology markets. Many US technological innovations originated in government research laboratories, a major characteristic of the Silicon Valley ecosystem.

Figure 5 shows trends across Australia's trading partners in Government expenditure on R&D.

**Figure 5: Government Expenditure on R&D as
a proportion of GDP (%): Australia's major trading partners**



Source: OECD [Main Science and Technology Indicators (MSTI database)](), Accessed 9 Feb, 2024

Across our trading partners, there has been a steady decline in Government R&D expenditure on R&D, with the notable exceptions of Korea and China. The decline in Australia has been particularly marked, from a peak of 0.41% for most of the 1990s to 0.17% in 2020.

Concluding comment

Australian R&D investment is in a poor state:

- Business R&D has collapsed.
- The government has failed to support R&D in its own research facilities.
- Higher Education R&D has increased on the back of international student fees.

The next Section explores the reasons for the collapse of business R&D. Without that understanding, we cannot develop solutions to our current problems. Looking back, we can tell what happened and why. Nonetheless, business organisations, lobby groups, and commentators will continue to act in ignorance and promulgate bad or inappropriate policy prescriptions.

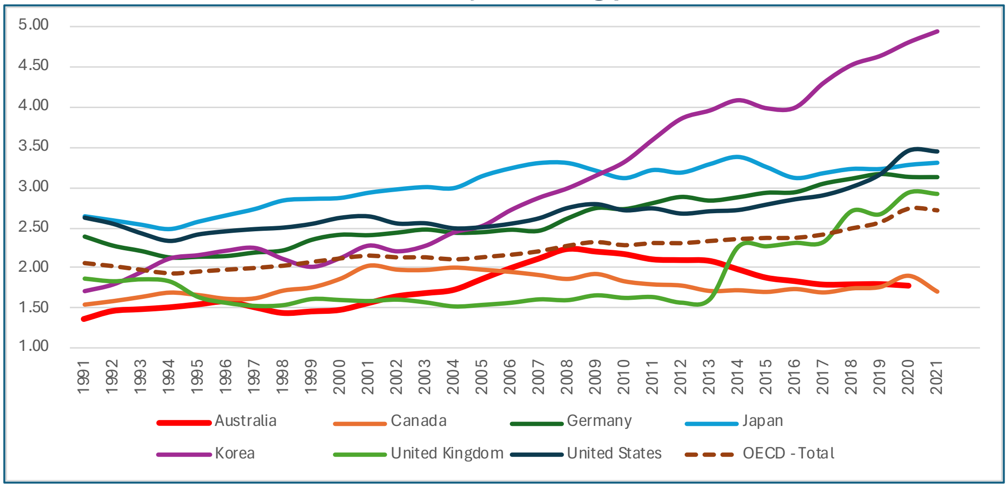
Why business R&D has collapsed

The influence of the GFC

The onset of the global financial crisis (GFC) was the most pivotal factor influencing the economic landscape in 2008. The GFC had profound implications for economies worldwide, causing a sharp contraction in economic activity and a decline in business and consumer confidence. Australian businesses were not immune to these global pressures, and the subsequent economic uncertainty likely played a substantial role in the observed reduction in investment.

A comparison with Australia's trading partners from 1981 to 2021 shows that Australia made progress in lifting the proportion of business R&D from a very low base (0.23% of GDP) until 1995 (0.82%) when the across-the-board tariff cuts announced in 1988 came into effect and the proportion dropped to 0.62% in 1999. It then recovered with the impact of the mining boom, reaching 1.37% in 2007 and then collapsed from 2008 to reach 0.92% in 2019.

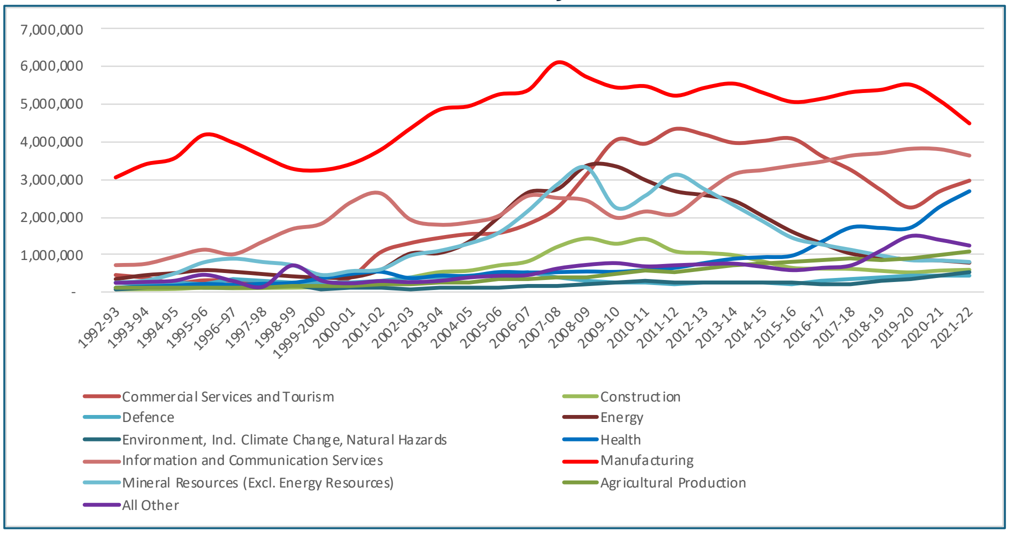
Figure 6: Business Enterprise Expenditure on R&D (BERD) as a proportion of GDP (%): Australia's major trading partners



Source: OECD Main Science and Technology Indicators (MSTI database), Accessed 9 Feb 2024.

As shown in Figure 7, the collapse in R&D expenditure has not been evenly spread across industry sectors.

Figure 7: Trends in business expenditure on R&D 1992-93 to 2021-22 $m inflation adjusted.



Source: ABS

The largest collapse has been in Energy R&D (black line), principally by fossil fuel companies, and has not been compensated for by investments in alternative energy sources. These predominantly overseas-owned and newly formed companies invest heavily in alternative energy R&D, but not much in Australia.

There has also been a decline in mineral processing R&D (light blue line) since 2008 as mining companies moved away from exploration to concentrate on extraction, obviating the need to develop new technologies[3]. Australia is benefitting from the extraction of new economy minerals, such as lithium, but is not benefitting from R&D in their processing.

Increased R&D investment in Information and Communication services from 2012-13 (light brown line), but a decline in commercial services and tourism since 2015-16 (dark brown line), although this has been recovering since 2019-20.

The downward trend in manufacturing R&D since 2020-21 is concerning, but COVID-19 might have influenced it. There is currently a concerted effort to build capability in advanced manufacturing through R&D investment in sensors and data analytics, advanced materials, smart robotics and automation, additive manufacturing (3D printing), and augmented and virtual reality[4].

Defence R&D does not take on the significance it does in the US and many other countries.

R&D in the Construction, Environment, and Agricultural production industry subsectors has been small. Again, global corporations invest heavily in R&D, but not much is undertaken in Australia.

Without the rapid growth in health R&D (mainly due to CSL), the situation would be even direr.

But there is more to it

Behind these trends, several institutional factors have been in play.

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[3] AlpaBeta, 2020. *Australian Business Investment in Innovation: Levels, trends and drivers*. A report prepared for the Office of Innovation and Science Australia. https://www.industry.gov.au/sites/default/files/2020-02/australian-business-investment-in-innovation-levels-trends-and-drivers.pdf

[4] CSIRO Futures, 2016. Australian Manufacturing: A Roadmap for unlocking future growth opportunities for Australia, CVSIRO, Canberra, Chapter 5. https://www.csiro.au/en/work-with-us/industries/manufacturing/advanced-manufacturing-roadmap

The imbalance in the Australian industrial structure.

Thirty-six Australian corporations rank among Forbes Global 2000. Financial information and the industrial sectors in which they are placed are detailed in Table 1 below.

Table 1: Australian companies in the Forbes 2000 by sector.

Sector	Sales	Percent of total	Assets	Market value
Finance	144.82	29.9%	3451.1	339.94
Retail	99.44	20.5%	54.82	87.95
Energy	86.29	17.8%	124.09	79.79
Minerals	92.63	19.1%	107.72	177.24
Manufacturing	17.07	3.5%	17.3	22.66
Technology	15.43	3.2%	28.63	33.7
Property, infrastructure, logistics	11.73	2.4%	75.15	79.38
Medical products and devices	17.66	3.6%	43.95	109.22
Total	485.07	100.0%	3946.51	984.53

Forbes, *The Global 2000, 2023* https://www.forbes.com/lists/global2000/?sh=7a025335ac04

Only a small number of businesses in these sectors are R&D intensive. BlueScope and Aristocrat, for example, invest heavily in R&D in the manufacturing sector. However, like Telstra in the technology sector, they are a very small component of Australia's industrial landscape.

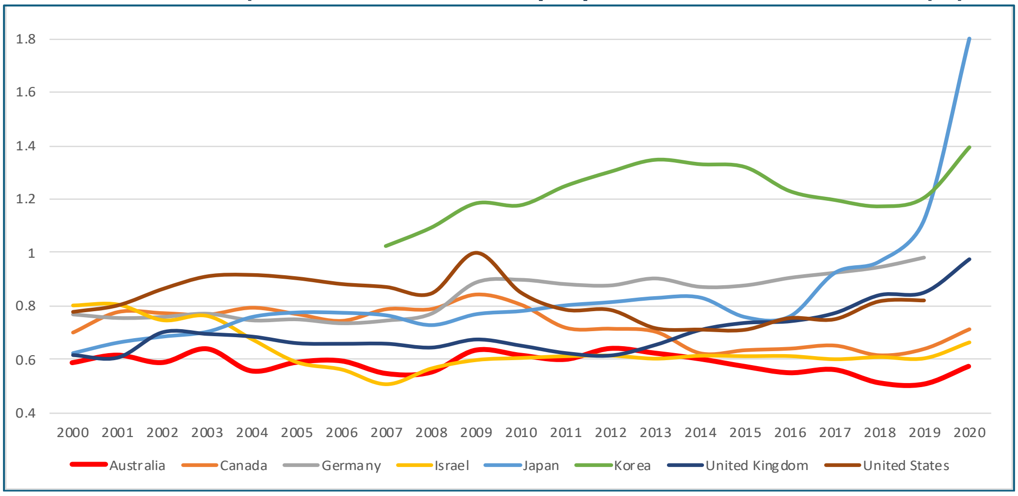
Australia's industrial structure is dominated by services, particularly Finance (nine businesses) and Retail (four). The resources sector (energy and minerals) accounts for 36.9% of the sales of Australia's largest companies. Several minerals and energy companies invest in R&D but tend to do this overseas.

Falling Government support for R&D

Governments support business R&D directly through their Budgets, through grants and subsidies, and indirectly through tax concessions and incentives.

The profile of government assistance for business R&D is shown in Figure 8

Figure 8: Government budgets for R&D and tax incentive support for business R&D (GBARD+GTARD - as a proportion of GDP 2000-2020 (%)

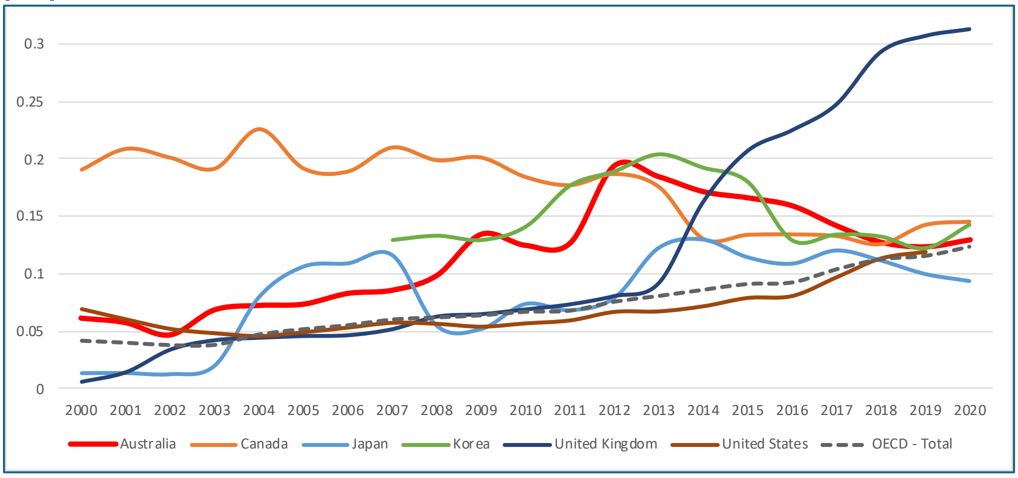


Source: OECD (2024), Gross domestic spending on R&D (indicator). Doi: 10.1787/d8b068b4-en (Accessed on 09 February 2024)

Again, Australia stands out as one of the few countries in the world where support for R&D has fallen since 2008, although there has been some recovery in 2020. The proportion fell in the USA but started to recover in 2016. Compared to other countries, Australia's support for business R&D verges on the tokenistic. While other countries have been increasing their commitment, Australia's commitment has fallen.

Over the years, Australia has placed increased reliance on tax incentives for R&D support. The level of support peaked in 2012 at 0.194% of GDP and has fallen back to 0.125% in 2020. Trends are shown in Figure 9.

Figure 9: Indirect government support through R&D tax incentives – as a proportion of GDP



Source: OECD https://stats.oecd.org/Index.aspx?DataSetCode=RDTAX#

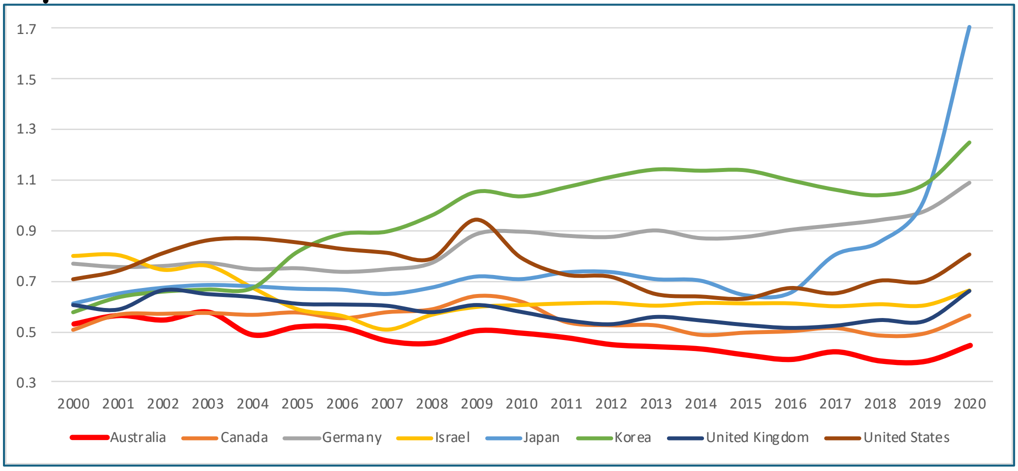
Germany and Israel do not have tax incentive schemes.

The Australian "flagship" program, the Research and Development Tax Incentive (RDTI) scheme, encourages businesses to invest in R&D through scientific inquiry and experimentation processes. Still, it does not require those businesses to adopt and implement their findings—in other words, to innovate.

The RDTI reflects the "linear flow" approach to scientific discovery, which is not how innovation happens in complex and dynamic innovation ecosystems.

Direct budgetary assistance for Business R&D shows a different profile among the peer groups. Korea, Germany, and, more recently, Japan have relied more on direct budgetary support, as shown in Figure 10.

Figure 10: Government budget allocations for Business R&D - as a proportion of GDP



Source: OECD, https://stats.oecd.org/Index.aspx?DataSetCode=RDTAX#

In contrast to the R&D Tax incentive, direct budgetary allocations in Australia have declined since 2003. Within this trend, there have been multiple policy shifts and program changes.

An unstable and unsupportive business investment climate

The 2008-2022 period was one where the government appeared disinterested in business R&D and sent confusing policies. During this period, 14 different Ministers had portfolio responsibilities for industry, science and innovation. These ministers are usually ranked at the lower end of the cabinet pecking order.

A regular grab bag of new initiatives ("funding programs") with very small amounts of money and very short half-lives, frequent machinery of Government (MOG) changes, public service "downsizings" that killed off policy capability and corporate memory, and "outsourcing" policy analysis to ill-equipped and under-skilled consultants in the global accounting firms.

Notwithstanding policy love affairs with small businesses, the history of technology indicates that big businesses drive investment in R&D. Those decisions are made based on a systematic analysis of cost, risk and return. Post 2008, without government interest, global businesses may have decided to defer R&D investment in Australia and/or undertake it elsewhere.

Critics argue that introducing new policies and uncertainty surrounding the Rudd Government's agenda may have contributed to a cautious approach among businesses. For example, the Resource Super Profits Tax (RSPT) proposed in 2010 generated significant controversy within the business community and may have influenced investment decisions.

The growing sophistication and cost of digitised R&D equipment

The cost of undertaking R&D has grown exponentially in recent years.

Researchers require access to high-performance computing systems (HPCs) such as IBM's Summit or the Cray supercomputers that provide the processing power necessary for tasks requiring extensive computational resources. These might include climate simulations, genomic sequencing, or complex physical simulations. Investment in these systems, while substantial, can yield significant returns by enabling cutting-edge research that would be otherwise impossible.

Graphics Processing Units (GPUs) like Nvidia's Tesla range have become indispensable for their parallel processing capabilities, which are crucial for AI and machine learning tasks. These GPUs accelerate the training of complex neural networks, making them essential for R&D in fields such as autonomous vehicles, facial recognition technologies, or real-time language translation systems.

Quantum computing represents the next frontier in computational power. Unlike traditional computers, quantum computers harness the principles of quantum mechanics to process information at speeds unfathomable to even the most advanced classical supercomputers. For example, Google's quantum computer, Sycamore, has demonstrated the potential to perform specific calculations exponentially faster than the best supercomputers available today.

Investment in quantum computing is a forward-thinking move that could revolutionise fields such as cryptography, materials science, and pharmaceuticals by solving complex, intractable problems.

On the software front, investments must be directed towards acquiring and maintaining up-to-date Software Development Kits (SDKs). For instance, Google's Android SDK for mobile applications or Apple's iOS SDK is critical for mobile app development, providing a suite of tools that enable developers to build, test, and deploy apps efficiently. Similarly, SDKs for web development like React or Angular are vital for creating interactive and user-friendly web applications.

Cloud-based SDKs, such as the AWS SDK for Java or Azure SDK for .NET, allow developers to utilise the extensive services provided by cloud platforms, such as data storage, machine learning, or serverless computing. These SDKs empower R&D teams to integrate cloud computing capabilities directly into their projects, facilitating scalability and reducing the need for expensive on-premises hardware.

Integrated Development Environments (IDEs) like Visual Studio or IntelliJ IDEA represent another software investment. These environments significantly enhance developer productivity with advanced code editing, debugging, and deployment tools. They are integral to modern software development, supporting a faster and more efficient development lifecycle.

The digitisation of R&D has also involved incorporating digital technologies into traditional laboratory instruments and industrial machinery. This transition has transformed once standalone devices into interconnected systems capable of complex data processing and sharing. For instance, modern analytical instruments such as mass spectrometers and high-performance liquid chromatography (HPLC) systems are now often equipped with digital interfaces that allow for advanced data analysis, automation, and remote operation (Smith, 2018).

The financial implications of acquiring state-of-the-art digitised R&D equipment are considerable. Developing, producing, and maintaining such sophisticated tools often require substantial investment. For example, the cost of high-throughput screening systems for pharmaceutical research can run into $millions, which can be prohibitive for smaller firms or academic institutions. The need for regular hardware and software updates and maintenance due to the rapid pace of technological advancement further adds to the long-term costs.

Access to cutting-edge R&D equipment is critical, particularly for smaller businesses undertaking research. In the manufacturing sector, the digitisation and sophistication of R&D equipment and the integration of advanced digital technologies into R&D are reshaping the industry. This can present both opportunities and challenges for countries like Australia.

These digitally enabled technologies include high-performance computing, 3D printing, CNC machines, robots and cobots, laser cutting, IoT sensors, AI quality control systems, AR/VR systems, HPC systems, advanced metrology equipment, PLM software, CAD/CAM software, and chemical analysis and material characterisation instruments. However, the sophistication of this equipment also raises issues around cost, access, and the requirement for specialised skills.

The high costs associated with these advanced technologies can challenge Australian manufacturing businesses, particularly small and medium-sized enterprises (SMEs) that form a large part of the sector. The initial investment required for sophisticated R&D equipment and the need for skilled personnel to operate and maintain this technology can be a significant barrier to undertaking R&D. The impact of this barrier on the level of business R&D is an issue worthy of further exploration.

Government investment in public research institutions is essential for broad access to sophisticated R&D equipment. Publicly funded laboratories support academic research and provide a platform for private-public partnerships, where private entities can leverage public resources for their R&D efforts (Bozeman, 2000).

The shift by global energy corporations to green technologies

Some have argued[5] that the business strategy of global oil and gas corporations (Woodside, Chevron, Santos, Shell, etc.) had shifted from exploration to production—although this did not commence until 2014-16.

[5] AlpaBeta, 2020. *Australian Business Investment in Innovation: Levels, trends and drivers*. A report prepared for the Office of Innovation and Science Australia. https://www.industry.gov.au/sites/default/files/2020-02/australian-business-investment-in-innovation-levels-trends-and-drivers.pdf

The annual reports of these corporations suggest that the focus of R&D has shifted to green energy technologies, such as hydrogen and renewables, but not much of it is occurring in Australia. For example, Woodside reports:

- A proposed liquid hydrogen project in Ardmore, Oklahoma, is expected to produce up to 60 tonnes per day (tpd) of liquid hydrogen. Woodside is evaluating the proposed US Federal Government tax incentive criteria to determine the project's implications and is working to finalise customer offtake agreements to support a potential FID.
- Woodside and Heliogen have a project agreement to deploy a 5 MW demonstration module of Heliogen's artificial intelligence-enabled concentrated solar energy technology in California, known as the Capella project.
- A proposed hydrogen and ammonia production facility in Perth, Western Australia, is progressing with a primary environmental approval application submitted to Commonwealth and Western Australian regulators in 2023.
- The Hydrogen Refueller @H2Perth is a proposed self-contained hydrogen production, storage and refuelling station that achieved an FID in 2023.
- H2TAS is a proposed renewable ammonia and hydrogen production facility in the Bell Bay area of Tasmania. In 2023, Woodside continued to evaluate power solutions and offtake opportunities.
- Southern Green Hydrogen is a proposed renewable ammonia production facility in Southland, New Zealand.1 In 2023, work continued to finalise commercial arrangements for Southern Green Hydrogen.

In 2024, the Chairman of Shell reported in The Company's *Energy Transition Strategy*[6]:

> We are increasing our investments in research and development and investing in future fuels. We aim to scale up new technologies to create affordable options for our customers into the 2030s. We are building Holland Hydrogen 1, one of the largest renewable hydrogen plants in Europe, close to our Energy and Chemicals Park Rotterdam in the Netherlands.
>
> We are also investing in carbon capture and storage technology to reduce emissions from our own operations such as refineries and LNG plants, and, in the longer term, to help our industrial customers reduce their emissions too.

In looking to the future, the *Transition Strategy* comments

> This decade, we are also focusing on developing integrated energy hubs, select carbon capture and removal businesses, such as CCS, and fuels of the future, such as hydrogen, to prepare to meet our customers' needs after 2030.
>
> We plan to create integrated energy hubs around our energy and chemicals parks in North America and north-west Europe, and other locations where we see significant potential for high growth in demand in the future. These include Australia, Brazil, China and India. We will be focusing our investments in these hubs as we integrate our businesses and trading capabilities to deliver affordable, low-cost solutions to our customers.
>
> We are researching the development of fuels such as liquefied synthetic gas (LSG), which is produced when renewable hydrogen is combined with captured carbon dioxide (CO2) to create natural gas, which is then liquefied. This low-carbon gas can be directly used in existing gas networks and infrastructure, including LNG plants.

Despite early solar and wind opportunities in Australia (e.g., in materials, size and scale), the data does not indicate a commensurate increase in Australian R&D in renewable energy

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[6] Shell plc, 2024, Energy Transition Strategy. 2024 https://www.shell.com/news-and-insights/annual-reports-and-publications/annual-reports-download-centre/_jcr_content/root/main/section/text_copy_copy_copy_.multi.stream/1711011674310/59e802290e686965f7bf81e2eee9d0d53e69ee92/ets24-print.pdf

research. The Renewable Energy Agency (ARENA)'s funding arrangements mean its impact will take time to materialise.

Fortescue, essentially a mining company, reported in 2023 that it would continue strengthening its presence *in the United States* and reaffirm its position as a global leader in green energy technology through the continued expansion, testing, and development of its Colorado Innovation Centre (CIC). The CIC will play a pivotal role in advancing green hydrogen and green energy innovations with a specific focus on decarbonising the most challenging industries.

> We are actively collaborating for the commercialisation of the technologies required to decarbonise our operations, create green hydrogen and green ammonia, and are applying these solutions across hard-to-abate sectors such as shipping and iron and steel production.
>
> Given the considerable challenge of achieving these goals, we have initiated a range of partnerships with research organisations, not-for-profit organisations, and consortiums to accelerate this work. We also fund research in other key areas of interest, including biodiversity and environmental stewardship.

The gravitational pull of globally oriented regional innovation ecosystems

Australian-formed and growing technology companies that have grown to global status, such as Atlassian, undertake their R&D in regional innovation ecosystems like Palo Alto, India, Boston, Oxford/Cambridge.

These places have grown through agglomeration effects and reflect, among other things:

- several diverse, research-intensive universities and institutes of technology and technical colleges with strong technology transfer offices
- a critical mass of patent attorneys and IP lawyers
- government-funded research institutes/laboratories
- global technology/biomedical corporations
- dynamic innovation incubators and accelerators
- sophisticated later-stage venture capital, private equity investors and investment banks/bankers
- innovation-supportive property developers and investors
- supportive regulatory frameworks (land use, building control, statutory planning)
- urban infrastructure and services
- arts and cultural facilities
- low-cost accommodation for PhD students and early career researchers
- an associative governance framework
- perhaps most importantly, a rich tapestry of social capital.

Australia does not yet have a regional innovation ecosystem with all or most of these characteristics, although places like Parkville and Clayton, Camperdown, and St Lucia come close. Attempts to generate one have been dominated by property developers seeking high returns on investment.

Establishing better linkages to international innovation ecosystems could achieve much more than policymakers' as to develop a “homegrown” and “ring-fenced” variety[7].

The challenge for educational institutions to keep up to date

Universities often face challenges in keeping pace with the sheer speed of technological advances. The bureaucratic nature of educational institutions can sometimes slow down

[7] Diagrammatic representations of innovation ecosystems in Australia invariably enclose them in a circle or ellipse, suggesting a closed system with no external or international connections.

curriculum updates, leading to a skills gap where graduates may not have the latest knowledge required by employers.

Moreover, there is a growing need for interdisciplinary programmes that combine technical skills with domain-specific knowledge, preparing students for the complexities of modern R&D projects.

Higher education institutions have not always been able to keep up to date with training and development programmes to ensure that R&D personnel remain adept at leveraging emerging technologies like quantum computing alongside traditional computational resources.

Many universities have made significant strides in integrating digital technologies into their curricula, establishing dedicated departments for computer science, artificial intelligence, and data science. They often partner with industry leaders to ensure that their programmes remain relevant and that students gain exposure to real-world applications.

Additionally, many universities are investing in their R&D facilities, providing state-of-the-art equipment and fostering an environment that encourages innovation among faculty and students.

Privatisations, mergers, and acquisitions

It is likely that the privatisation of energy production and distribution corporations, particularly in NSW[8], significantly impacted R&D investment.

When government-owned, business enterprises plough back profits into R&D. When privatised, surplus profits are returned to shareholders. There is very limited information about how privatised enterprises are committing to R&D in renewable energy.

The largest energy suppliers in Australia are Origin Energy, AGL Energy, and Energy Australia. None of these companies, which absorbed the State-owned suppliers, mention research or R&D in their Annual Reports. In 2022, Snowy Hydro reported a $0.5 billion R&D offset.

Australian Defence Industries was privatised in 1999, passing from government ownership into the hands of 50:50 partners Transfield of Australia and French defence company Thompson-CSF, later to become Thales. Thales undertakes research on a global basis, locating activities where it can secure the best deals with host governments and research organisations. In 2024, Thales reported that it would spend $100m in self-funded R&D over the next three years[9].

Other Australian defence industry companies were also privatised and subsequently acquired and developed by international defence primes, who, by the late 2000s, brought significant capability and technology to the Australian defence market[10]. But the extent to which that technology has been developed in Australia is uncertain.

Recent research has suggested that privatised firms focus on a narrower set of technologies as a response to increased pressure for profitability and short-term results, and privatisation will increase the extent to which they collaborate with external inventors, both locally and internationally. Research also suggests that overall patenting activities, and in particular

[8] The OECD Frascati Manual defines Business Enterprise R&D "to cover both private enterprises (either publicly listed and traded or not) and government-controlled enterprises, which in this manual are termed "public enterprises"" (page 201). For public enterprises, the borderline between the Business enterprise and Government sectors is defined by the extent to which the unit operates on a market basis, i.e. whether its principal activity is the production of goods or services for the market at economically significant prices

[9] About Thales in Australia, 2024. https://www.thalesgroup.com/en/asia-pacific/australia/about-thales-australia

[10] AiGroup, 2023. *Defence Industry in National Defence Rethinking the future of Australian defence industry policy*, Australian Industry Group and Strategic and Defence Studies Centre, Australian National University, p.10. https://www.aigroup.com.au/globalassets/news/reports/2023/ai-group-sdsc-dind-report.pdf

overseas collaboration in technological innovation, are associated with greater firm performance, but only after privatisation[11].

A paper released in 2012 suggests that the restructuring of the electricity industry reduced R&D investment, which may be detrimental to the reliability and efficiency of the electricity system as well as to the creation and maintenance of the innovation capabilities necessary to address demand and environmental concerns[12].

The globalisation of corporate R&D

With the progressive takeover of Australian business by multinational and global corporations and the increasing role of private equity firms in initial public offerings (IPOs), leveraged buyouts, mergers and acquisitions, R&D is being cut back or eliminated entirely unless there is a compelling, distinctive capability to be nurtured locally.

VC firms that invest at scale in building R&D start-ups (e.g., pharmaceutical or software start-ups) tend to make those investments where the innovation ecosystem is strong—San Francisco and Boston, for example. Atlassian provides an interesting example of a decision to stay in Australia.

Global R&D-intensive businesses make decisions about where to locate R&D investments and access capability on a global basis. It is incorrect to say that these businesses like to locate their R&D close to home and their domestic markets.

Global R&D-intensive businesses consider the strength of talent pools, research capacity and capability, ease of doing business, potential partnership arrangements with universities and public research organisations, trust, and the availability of government support. The competition among regions to participate in these networks and value chains is intense.

The once-large corporate R&D labs are disappearing, and R&D is becoming more distributed. In an interview for *Mining Technology Magazine* 15 years ago[13], the global head of innovation at Rio Tinto foreshadowed the trends in the following terms:

> R&D investment is distributed and operates in global technology markets, where multiple suppliers provide expertise and capability in networks and value chains. Rio Tinto is committed to leveraging external centres of excellence in creating the ‘mine of the future’. Undoubtedly, new alliances and structures will emerge as we pursue this vision.
>
> We have deliberately refrained from building large in-house centres to handle this new wave of innovation work – the world is increasingly an interconnected and interdependent place and we believe our core skill lies in identifying the challenges, visioning the mine of the future and coordinating the resources to best attack the problem. You should assume this will be our modus operandi going forward.
>
> I cannot speak for the rest of the mining industry in this regard, though I am aware that some of our competitors choose to pursue their own ‘mine of the future’ programmes with predominantly in-house resources, while others seem more aligned with Rio Tinto’s way of working.
>
> Whatever happens in the future, I am personally convinced that the wider network of mining houses, suppliers, research institutes and world-class universities will have to rise to the challenge we collectively face. Indeed, this will be an interesting time for our generation and, I suspect, for those who will come after us.

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[11] Somé, H. Y., Cano-Kollmann, M., Mudambi, R., & Cosset, J. (2021). The effect of privatization on the characteristics of innovation. *Financial Management*, *50*(3), 875–898. https://doi.org/10.1111/fima.12311

[12] Kim, J., Kim, Y., & Flacher, D. (2012). R&D investment of electricity-generating firms following industry restructuring. *Energy Policy*, *48*, 103–117. https://doi.org/10.1016/j.enpol.2012.04.050

[13] Rio and the Future of R&D, *Mining and Technology,* June 18 2008, https://www.mining-technology.com/features/feature2040/?cf-view

Many large global R&D-intensive businesses have a presence in Australia, but the presence is for making sales, not for undertaking R&D. Where there is a presence, the scale of operations is small.

Few global agtech corporations undertake R&D in Australia or have relationships with Australian public research organisations and universities—apart from students. In the Agriculture sector, companies like Bayer, Syngenta, and BASF have global R&D programs, and competition between countries to access them is intense[14].

Australia is currently uncompetitive in the global R&D business. Although this issue was recognised many years ago, Australia has not developed a Foreign Direct Investment (FDI) policy to attract R&D investment. Instead, the Australian States compete with each other to attract FDI to "create jobs" ("any jobs"), possibly sending mixed messages to investors.

The situation is exemplified by the Australian Innovation Research Group's decision to close its operations and become absorbed within the Australian Industry Group. Consequently, Australia no longer has a dedicated advocacy body for corporate R&D.

Investor pressure for shareholder value

Using profits for share buybacks rather than global growth through R&D. Australian Boards have been interested in, and CEOs are rewarded for, increasing their share price and shareholder value. Greater commitment to R&D is more likely with a tightly held share register and growing companies remaining privately owned. Paradoxically, the Telstra and Qantas share buybacks have not lifted shareholder value.

How other countries avoided a collapse in business R&D

Other countries managed to avert the collapse of business R&D in the wake of the GFC. In the USA, Germany, Korea, and Japan, for example, R&D expenditure increased significantly after the GFC.

These countries already had a strong industrial base in high-tech and manufacturing sectors, which traditionally invest heavily in R&D. Post-GFC, governments in these countries implemented policies that either directly supported R&D investments or created an environment conducive to such investments. For example, the USA's Recovery Act included substantial funding for R&D. Similarly, both Korea and Japan have long-standing policies supporting industrial technology development and innovation.

In Australia, however, despite avoiding a recession, the recovery leaned heavily on the mining boom, which drew resources away from sectors that traditionally contribute more to R&D. Additionally, Australia's industrial base was less concentrated in high-tech manufacturing, which typically sees higher R&D expenditure. Australia is now in a "catch-up" phase with some commitment to advanced manufacturing and quantum science. But the amounts are small in the overall (global) scheme of things.

In addition, the USA, Germany, Korea, and Japan had robust institutional frameworks supporting R&D through direct funding, tax incentives, and partnerships between industry and academia. *Their policies are designed to enhance competitiveness in technology and innovation on a global scale*. As noted above, Australia had been cutting back on budgetary support for R&D and placing reliance on a single instrument—the RDTI.

Moreover, Australia's focus on immediate economic returns from mining diverted attention and resources from long-term investments in R&D across other sectors.

[14] In 2022 Bayer reported over 700 collaborations, twelve of which were in Australia but none involved Agriculture. This compares with 14 in Canada, two of which involved crop science. https://www.bayer.com/en/sustainability/transparency-in-science-collaborations In 2019, Bayer generated sales of A$1.3 billion in Australia and New Zealand.

Finally, the USA, Germany, Korea, and Japan viewed investment in R&D as a strategic priority for economic recovery and future competitiveness. Stimulus measures in these countries included significant budgetary allocations for science, technology, and innovation. In contrast, Australia, where the immediate impact of the GFC was less severe due to the mining boom, led to complacency in other sectors regarding the need for R&D investment as an engine for growth.

While beneficial in the short term, the economic stability may not have provided the same impetus for strategic investment in R&D as seen in countries that experienced more significant economic downturns.

The divergence in R&D expenditure trends post-GFC between Australia and countries like the USA, Germany, Korea, and Japan underscores the importance of strategic, consistent, and sector-specific support for R&D. Australia's experience suggests that reliance on a single economic sector, even one as lucrative as mining, can have unintended consequences for innovation and long-term competitiveness.

Conclusion

A recent report to the Government set out directions for change and opportunities that should increase business investment in innovation[15]. It advised—

> "The wide engagement with businesses through this study led to the conclusion that governments can help businesses invest more effectively in innovation through:
>
> - constructing an inclusive and compelling narrative on innovation
> - consolidating, redesigning and coordinating grant programs
> - concentrating support to build thriving industry ecosystems
> - fostering collaborations, including between business and government
> - using procurement to drive innovation
> - improving the foundations for businesses
> - working more effectively with business to build skills.

The policy directions outlined in the report were developed through "a co-design process involving businesses and government staff engaged in industry policy". The report asserts that the identified directions for change will improve what it identifies as the "four elements that work together to increase businesses' capacity and inclination to invest in innovation – desirable internal characteristics, more opportunities, reduced risk and a thriving industry ecosystem."

As the authors note, these normative prescriptions are not new. They were canvassed 27 years ago in the Australian Business Foundation Report *The high road or the low road? Alternatives for Australia's future*[16] have been repeated many times since—in the 2008 Cutler Report *Venturous Australia: Building Strength in Innovation*[17], and the 2017 Ferris Report, *Australia 2030: Prosperity through Innovation: A Plan for Australia to Thrive in the Global Innovation Race*[18].

A feature of Australian public policy formulation is that it reacts to symptoms of problems rather than their underlying causes. Solutions are often cloaked as slogans, cliches, and quick fixes, which are generally impossible to implement or unlikely to have any impact. And this has been

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[15] Nous Group, 2019. Policy directions to increase business investment in innovation. A report for the Office of Innovation and Science Australia. https://www.industry.gov.au/sites/default/files/2020-02/policy-directions-to-increase-business-investment-in-innovation.pdf

[16] See Marceau, J., Manley, K., & Sicklen, D. (1997). The high road or the low road? Alternatives for Australia's future, Australian Business Foundation. Available at https://eprints.qut.edu.au/216147/1/41292.pdf

[17] Cutler, T 2008, Venturous Australia: building strength in innovation [Cutler review], Department of Innovation, Industry, Science and Research, Canberra. https://www.voced.edu.au/content/ngv%3A12472

[18] Innovation and Science Australia & Howard Partners 2017, *Australia 2030: prosperity through innovation: a plan for Australia to thrive in the global innovation race*, Department of Industry, Innovation and Science, Canberra, viewed 25 Mar 2024, https://industry.gov.au/Innovation-and-Science-Australia/Australia-2030/Pages/default.aspx. https://www.voced.edu.au/content/ngv%3A78843

going on for 30 years in science, research, and innovation policy. Curiosity is shunned, analysis is highly empiricist, and reliance is placed on the voices of numerous stakeholders elicited through "consultations."

The recent *Australian Universities Accord Report* has recommended a "root and branch" review of Australia's research funding system. Can we realistically expect that the Report coming from this process will be any different?

This diagnosis in this Paper suggests a multifaceted and more deep-seated approach is required to address the systemic issues that have been canvassed, particularly in relation to global business R&D investment patterns. Understanding these issues in an Australian context will come through a combination of theory and data-driven research and analysis.

Hypotheses about the causes of problems must be developed and tested, and options for resolution must be assessed for their practicality, feasibility, and effectiveness. We cannot always rely on the collective wisdom of the crowd that will miraculously reconcile a very wide range of diverse and conflicting views.

Constitutional frameworks and institutional structures are given and changing them does not guarantee that a new successful strategy will emerge. Committed action by Government and Business is required to go anywhere near the 3% R&D as a proportion of the GDP target.

How to Reverse the Slide

Australian business investment in R&D collapsed during the Global Financial crisis and has not recovered. This calls for a strong government policy response and a full-bodied commitment from the business sector. This paper advocates a *National Business Research and Development Strategy and Action Plan* as an essential component of the response.

Five policy initiatives

This paper canvasses five core policy initiatives that would strengthen Australian business R&D commitment and secure a path to knowledge-driven growth. This pathway will involve supporting and stimulating R&D in businesses that constitute *the Industries of the Future* and steer the economy away from reliance on the export of commodity materials.

Five initiatives to reverse the slide in Australian Business R&D

1. An integrated strategy of targeted public support for business R&D
2. A massive lift in public research investment through public research organisations
3. An active and coordinated foreign direct investment (FDI) program targeted at large global R&D investors.
4. Sustaining the investment commitment to education and skills development to support these industries.
5. Ensure that businesses in the industries of the future are effective partners in the development of innovation districts, precincts, and hubs.

These initiatives would be embedded in a *National Business R&D Action Plan*.

Addressing and executing these initiatives would go a long way to ensuring that Australia enters the elite group of countries that spend over 3% of GDP on R&D.

An integrated strategy of targeted public support for business R&D

This strategy would cover—

- A cross-portfolio suite of programs that targets business investment in the industries of the future[19], designed for medium-sized technology-intensive enterprises with the potential to grow and prosper through export.
- A modified R&D Tax Incentive program that targets specific technologies in the industries of the future.
- A direct investment strategy that encourages businesses to invest in R&D that is directed towards exploring and discovering new ideas and technologies that may not have an immediate commercial application.
- A Public-Private Partnership (PPP) program that invests in infrastructure and facilities that encourage collaboration with universities and public research organisations
- A Research Facilities Access Program that supports business access to national and international research facilities and equipment for the purposes of testing, scaleup and prototyping.
- A National Technology and Knowledge Transfer program to support university and public research organisation technology transfer offices (TTOs)[20]. Currently, there are no government programs that support TTOs.

Elements of these programs are in play in Australia by the Commonwealth and the States acting individually, but they are disconnected and often lack scale and critical mass. They do not add up to an integrated national R&D strategy. The *Future Made in Australia Act* is potentially an important vehicle to address this.

A massive lift in public R&D investment

Government investment in public research is essential for building business-government collaborations in areas of applied research and experimental development and providing businesses with access to sophisticated R&D equipment[21]. This is fundamental for building the industries of the future.

There is little doubt that Australian public research has been substantially defunded over the last 15 years. This trend must be reversed.

The case for supporting public research is even more compelling when it is realised that in today's world, the "three horizons" approach to strategy is no longer bounded by time. Public research organisations can be forward-looking, agile, and responsive to technology signals and scenarios to lead the deployment of resources to Horizon Three projects.

This initiative would cover existing public research organisations (CSIRO, ASNSTO, DST, and State Agriculture Departments) and, where required, new national research institutes/laboratories established to focus on the specific technological capabilities required to grow the industries of the future.

An active and coordinated foreign direct investment (FDI) program

Having regard to the intense competition among countries and regions to attract global business R&D investment, an active and coordinated foreign direct investment (FDI) program is essential. It would involve the following basic elements:

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[19] Although there is no specific definition, the industries of the future are generally identified as clean energy, advanced manufacturing, autonomous systems, quantum technologies, electric vehicle components, battery manufacturing, and biomanufacturing. The issues were discussed more fully in the 2020 UTS Occasional Paper, Challenges for Australian Research and Innovation.

[20] Would cover CSIRO, DST, ANSTO, Rural RDCs, and Medical Research Institutes.

[21] It is significant that CSIRO has recently purchased a sophisticated multi-metal 3D printer. See "First multi metal 3D printer in Australia to boost aerospace manufacturing", https://www.csiro.au/en/news/All/News/2024/March/First-multi-metal-3D-printer-in-Australia-to-boost-aerospace-manufacturing

- *A policy framework that provides clarity and stability*—including guidelines on intellectual property rights, taxation incentives and obligations, regulatory requirements, grants, research funding, and principles for customised support services.
- *Target identification*—analysis of global R&D investment trends and target sectors and investors.
- *A compelling value proposition*—highlighting the benefits of investing in Australia, including access to talent, infrastructure, research institutions, and supportive regulatory frameworks and how it would deliver strong investor ROIs.
- *Direct engagement with target investors*—through a comprehensive program of targeted outreach efforts.
- *Promoting knowledge exchange and technology transfer, including collaboration between R&D investors, higher education, public research organisations,* and specialised R&D providers.
- *Support for public-private partnerships*—to co-fund and co-implement initiatives that support the objectives of the FDI program.

The FDI program would be based on a *mindset of collaboration*—between government agencies (Commonwealth and State), industry and professional associations, research institutions, and other stakeholders to leverage complementary strengths and resources.

The FDI program would Incorporate mechanisms for monitoring and evaluation, including key performance indicators (KPIs) such as investment inflows, job creation, and innovation outcomes.

Sustaining the investment commitment to education and skills development to support the industries of the future

Investment in education and skills is fundamental to building and sustaining the industries of the future.

Universities and TAFE/VET institutions still face challenges in keeping pace with the sheer speed of technological advances. They can sometimes be slow to update their curriculums, leading to a skills gap in which graduates may not have the latest knowledge required by employers.

Moreover, there is a growing requirement for interdisciplinary programs that combine technical skills with domain-specific knowledge, preparing students for the complexities of modern R&D projects.

Many universities have made significant strides in integrating digital technologies into their curricula. They partner with industry leaders to ensure that programs remain relevant and that students gain exposure to real-world applications.

The newly established Tech Council acknowledges this problem, but there is a lot of catching up to do.

A *New Industries R&D Skills Development and Talent Retention Program* is required to ensure that Australia's industries of the future will have the people with the required knowledge, skills and capabilities that will ensure that businesses in these industries will have the capability to grow and prosper.

Business engagement in innovation districts, precincts, and hubs

At the present time, innovation districts do not receive targeted financial support from the Commonwealth Government, although districts may tap into a range of urban and regional development funding programs.

Moreover, State Government and private sector investments mix the R&D objectives of participating higher education and public research organisations with the business models of property developers, the urban renewal and regeneration objectives of State and local governments, and the rhetorical technology visions of business and financial elites.

In the US, the Biden administration has commenced an initiative to designate selected communities across the country as Regional Innovation and Technology Hubs (Tech Hubs). Tech Hubs are intended to catalyse investment in technologies critical to economic growth, national security, and job creation and help communities become centres of innovation critical to American competitiveness.

The Australian Government must designate and financially support the development of innovation districts and hubs to ensure that they support the development and growth of Australian industries in the future. Tonsley Park in South Australia is often held out as an exemplary case example, but there are other examples of good practice.

A rigorous approach for adoption and implementation

it almost goes without saying that Australia requires a *National Business Research and Development Strategy and Action Plan*.

This should be orchestrated by the Prime Minister and the Minister for Industry and Science through the Australian National Science and Technology Council. It should not be outsourced to an independent Review.

The development of the Strategy and Action Plan must involve rigorous analysis and testing of propositions not only in terms of their desirability but also in terms of their practicality and feasibility.

Many previous reports on lifting business investment have tended to use the "wisdom of the crowd" through extended consultations and relied less on the knowledge contained in previous reports, understanding why they have not had an impact and the input of national and business development experts.

Very few recent reports have seriously addressed the FDI or global R&D sourcing issues. Recent studies of business R&D investment and industry policy do not mention foreign direct investment at all[22].

A team of officials and key stakeholders should support the formulation of the Strategy and Action Plan rather than outsourcing it to consultants.

Delivering outcomes: a National Business R&D Strategy and Action Plan.

The Challenge: public administration is complex

The structure of the Australian Government's R&D landscape is a rich tapestry of research-performing and research-funding organisations, delivery agencies, advisory and coordinating bodies, and arrangements for stakeholder engagement within the "Machinery of Government".

[22] Office of Industry, Innovation and Science, 2024. *Barriers to Collaboration and Commercialisation*; Centre for Policy Development, 2024. *Setting Direction: A purposeful approach to modern industry policy*; and Office of Industry, Innovation and Science, 2019. *Policy directions to increase business investment in Innovation*.

The Machinery of Government

The "division of work" within the government, or the "machinery of government", is determined by the Governor General on the Prime Minister's advice. It reflects political significance, factional bargains, ministerial seniority, ministers' preferences, and regional representation.

The Machinery of Government is therefore an imperfect structure of programs and activities that reflects functional, customer/client, operational, and locational concerns. The current machinery is defined in the Australian Government Organisations Register, which includes 1,334 entities and bodies classified into 12 categories[23].

Many of these entities have been established by legislation or Ministerial direction to carry out specific functions, such as Industry, Innovation and Science Australia, The Australian Space Agency, The Industry Capability Network, Silicon Quantum Computing Pty Ltd. Most are there to implement policy, rather than develop it.

The Machinery of Government is "noisy," with a multitude of advocacy and representative groups seeking to convey their views and interests to decision-makers through an increasing variety of channels. These groups often demand the creation of a new entity or the expansion of an existing one to represent their interests.

It is also dynamic. Entities are created, redesigned, or abolished almost continuously. Rather than extending programs and arrangements to accommodate new policy initiatives, Ministers and their advisers often like to ensure longevity with new legislation and regulations[24].

The situation is replicated at the State/Territory Government levels, alongside numerous Commonwealth-State consultation and collaboration arrangements.

The reality is that the conduct of modern-day public administration and public policy is inherently complex and sometimes seen as "overloaded"[25]. The task of coordination is immense—and imperfect. There are often attempts to reduce this overload but with limited impact. It continues to expand.

The "Machinery" for the development and implementation of science, research, and innovation policy

Ministries and departments

Australia has 16 Ministries, 14 of which deliver research programs. They include Education (university research), Industry, Science and Resources (industrial research), Health (health, biomedical and clinical sciences), Agriculture, Defence, and Climate Change, Energy, The Environment, and Water.

Within Ministries, there are departments, statutory authorities, and government business enterprises; numerous Government-appointed boards, commissions, councils, and other boards and structures. For example, the Ministry of Industry, Science and Resources hosts 10 Government-appointed boards and 21 other boards and structures.

Statutory research investment councils

Australia has two principal research investment councils: the Australian Research Council and the National Health and Medical Research Council. These operate independently from Ministers, within the provisions of their enabling legislation and the funds assigned to them

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[23] Department of Finance, *Australian Government Organisations Register,* 2024. https://www.finance.gov.au/government/managing-commonwealth-resources/structure-australian-government-public-sector/australian-government-organisations-register

[24] The previous Government's *Higher Education Research Commercialisation Action Plan* was legislated by an amendment to the Higher Education Support Act – *the Higher Education Support Amendment (Australia's Economic Accelerator) Act* 2022.

[25] See, for example, Howard, John H (1984). Extended Essay: Perspectives on Overloaded Government, *Australian Journal of Public Administration*, XLIII (4), December 1984, pp332-403.

each year recommended by the Government and approved by the Parliament (Appropriation Acts).

There are five statutory rural research and development corporations and ten industry-owned research and development companies that have been established under legislation.

Publicly funded research agencies (PFRAs)

Publicly funded research agencies have been established to undertake mission-directed research of national priority and benefit.

They include the Commonwealth Scientific Industrial Research Organisation (CSIRO), the Australian Nuclear Science and Technology Organisation (ANSTO), Geoscience Australia and the Defence Science and Technology Group.

Medical Research Institutes (MRIs)

Australia has 58 medical research institutes. The majority are mission-driven charities that operate independently from Government, a university, or a hospital.

They receive their research funding through the National Health and Medical Research Council, The Medical Research Future Fund, other Commonwealth and state government payments for research support and infrastructure, competitive grants from foundations and trusts, commercial income, and philanthropic donations.

Revenue agencies

The Treasury and the Australian Taxation Office administer the corporate tax system. They have key roles and responsibilities regarding the recognition of corporate R&D expenditures and the administration of the Research and Development Tax Incentive (RDTI). The Department of Home Affairs administers the *Customs Tariff Act*.

Specialised program delivery agencies

In many countries, the roles of policy development and program delivery agencies are separated. This is not as clear in Australia, where policy agencies also have responsibility for program and project delivery.

The Government has created a broad range of agencies specifically to implement and deliver policies. They are too numerous to list here, but they include:

- *Divisions within Departments*, such as AusIndustry and the Australian Space Agency
- *Statutory Authorities*, including the National Reconstruction Fund Corporation, the Net Zero Economy Authority, IP Australia, and Industry, Innovation and Science Australia. Some authorities are managed as Divisions within a Department.
- *Statutory positions* within Departmental structures, including the Australian Industry Participation Authority
- *Companies* created under the Corporations Act, including the Industry Capability Network Limited, The Australian Measurement Institute, the ANU MTAA Super Venture Capital Initiative

Support Machinery

Numerous formally recognised and often legislated advisory councils and committees interact with the R&D Machinery to provide research, advice, guidance, and direction. They include—

The National Science and Technology Council

The Council is responsible for "providing advice to the Prime Minister and other Ministers on important science and technology issues facing Australia". This covers—

- Long-term and emerging scientific and technological developments
- Scientific and technological issues of relevance to Government policy or priorities
- Australia's science system, including issues relating to science engagement, research capability and science, technology, engineering, and mathematics (STEM) education and workforce skills
- Achieving the Government's objectives as set out in the National Science Statement
- Other matters requested by the Prime Minister, other ministers, or considered important by the Council.

The Council's membership is the Prime Minister (Chair), the Minister for Science (Deputy Chair), the Chief Scientist (Executive Officer), the Chief Executive of the CSIRO and up to six scientific expert members.

The Council does not appear to have reached its full potential in the context of the issues raised in this series of Papers. Moreover, no scientific expert members are drawn from the business community. Given Australia's exceptionally poor performance in business R&D, this should be addressed.

The *Chief Scientist* also provides strategic advice to the Prime Minister by leading and participating in several other advisory bodies, including Industry Innovation and Science Australia, the Forum of Australian Chief Scientists, the Government Scientists Group, the National Data Advisory Council, and the National Climate Change Authority Board.

The learned academies

Australia has five learned academies, which are recognised formally under the Higher Education Support Act and are united under the umbrella of the Australian Council of the Learned Academies (ACOLA).

Their important science and research policy role often goes unrecognised. There is perhaps an issue with "receptor arrangements" regarding how their research projects and outcomes feed into the science and research policy infrastructure.

Science and research representative organisations

Australia has formal and informal university and non-university groupings representing and advocating for their members' interests, including research investment. Prominent among them is the Tech Council of Australia.

Professional associations

Associations of scientists, engineers, architects, and designers play a major role in accrediting courses as a qualification for entry into their professions. They have also increased their advocacy and "government relations" activities to represent their points of view.

Organisations that promote university-industry collaboration

Business-higher education collaboration organisations are important in promoting collaboration and partnership between universities and businesses. In some counties, formal arrangements exist, such as business-higher education roundtables.

An Australian BHERT operated in the early years of this century but is now defunct. Key stakeholders may consider measures to revitalise the Australian Business-Higher Education Round Table using overseas practice as a guide.

Knowledge brokers, knowledge exchange networks

Many countries have developed knowledge brokerage, knowledge networks, and knowledge mobilisation arrangements. However, the approach is inconsistent; only a few countries have embarked on centrally coordinated initiatives. Fewer have developed arrangements for research brokerage.

Over the last 20 years, the Australian Government has experimented with several intermediary programs. Currently, the AusIndustry Innovation Connections program supports collaboration between small and medium-sized enterprises (SMEs) and academic researchers.

Where to from here?

There are two fundamental elements in charting a path forward; both relate to the principle that strategy is more important than structure.

A National Business Research and Development Strategy and Action Plan.

There is little doubt that the Australian research funding and delivery system is complex and appears disjointed and unconnected. But these characteristics apply in other countries.

The Australian business R&D support framework is currently a loosely connected set of programs and interventions that operate within Commonwealth Ministerial Departments and statutory authorities. State and Territory Governments also maintain programs and interventions to support business R&D.

Policy analysts and management advisers know that a good policy or strategy can be delivered through any structure, *provided that* implementation and delivery directions are clear, resources (skills, knowledge, funds, technology) are available, and responsibility and accountability frameworks are in place.

Those provisions are not in place. Australia requires a *National Business Research and Development Strategy and Action Plan* to address the deep-seated problems that materialised with the collapse of business R&D since 2008.

Off course implementing the Strategy and Action Plan through existing structures could be inefficient, time-consuming, and expensive, fraught with the exigencies of bureaucratic silos and turf wars. A strong case for a new arrangement to cut through administrative morass can be made.

A national science/research foundation

Looking internationally, in presidential systems of government, national science/research foundations have been a major force driving research investment. Creating an Australian National Research/Science Foundation, building on the models of Germany, Israel, Korea, and the USA, is an attractive option for Australia.

The processes required for establishing the Foundation could be disruptive, involving major changes to the existing research investment infrastructure, but it could also deliver transformational change.

An Australian Science/Research Foundation would still operate alongside the research investment responsibilities of Ministerial Departments and statutory authorities—as is the case in Germany and the USA, for example.

The Australian Science and Research Foundation could be a significant game-changer for Australian business (and government and higher education R&D).