ACTON INSTITUTE FOR POLICY RESEARCH AND INNOVATION

Institutions in National Research Systems: An International Comparative Analysis

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Preface

This is a report of a Study of university research and research funding systems in Canada, Germany, Israel, South Korea, the UK, and the USA, how they interact with the innovation ecosystems and how they compare with the Australian research system and broader innovation ecosystem.

The study focused specifically on the higher education component of public research systems. The other major component of public research is government research, undertaken in a wide variety of specifically constituted government research organisations, institutes, and laboratories. In addition, a significant amount of government research is undertaken *within* Ministries/Departments to support their own specific missions.

Public research can also include research undertaken by private, not-for-profit organisations, such as medical research institutes, which receive funds from philanthropic sources and substantial amounts from the government.

While institutionally separate, higher education research engages with government research in a variety of ways. These include being a partner in a research institute, an eligible or targeted recipient of funds from government research funding programs, or a contractor for government research projects commissioned by ministries/departments.

In some countries, policy and operational responsibilities for higher education and government research are closely connected and integrated; in others, they are managed separately in different Ministries/Departments. Australia has experimented with both approaches. Currently, they are separate.

Also, in some countries, responsibility for higher education research is housed alongside government research in a specific Ministry, such as the German Ministry of Research and Education. In contrast, in other countries, responsibilities sit with a broader science, technology, and innovation agency remit.

In Australia, funding for university research is primarily the responsibility of the Department of Education. The Department funds 28.7% of Australian Government support for R&D, most of which goes to universities[1]. But, as indicated, universities receive funding for research from numerous other Australian Government programs[2] as well as from businesses, from State/Territory Governments, from overseas, from charitable organisations, and from their own resources.

There are also major differences in the extent to which university and government research contribute to the national research effort. In the UK and countries that inherited the British system of cabinet government and individual Ministerial responsibility, the proportion of higher education in the national R&D effort has, over the last 20 years, been in the range of 25-35%. This constitutes a very significant role in the overall public research system.

The approach to public research funding in these countries represents an aggregative “bottom-up” style of decision-making and resource allocation—decisions made by numerous funding bodies ranging from independently operating Ministries/Departments and research councils to decisions of universities and public research organisations using their own funding sources. None of the countries has a long term national research strategy, and the proportions of R&D to GDP languish below 2%.

[1] The proportion increases to 38.9% if the Research and Development Tax Incentive is excluded.

[2] Responsibility for funding other dimensions of public research rest with many other Australian Government Departments—principally Agriculture, Climate Change, Energy, Environment and Water, Defence, Health and Aged Care and Industry Science and Resources. A detailed listing of programs over $10m administered by these Departments is at Addendum 1 on page 91.

In Germany, Israel, and the USA, the higher education contribution to national R&D is much less—in the 10-20% range. These countries reflect different public administration traditions, such as the hierarchical rational-legal style in Germany and the Presidential style in Korea and the USA.

These countries have a national research foundation that takes a cross-government approach to public R&D investment. Israel is an outlier, with a falling proportion of higher education research in national R&D and a small government research component[3].

In Korea, the contribution of higher education research has fallen to below 10%. However, Germany and Korea have much higher proportions of government research in their public research systems, lifting the overall contribution of public research to GDP.

These countries tend to reflect "top-down" strategic approaches to decision-making and resource allocation in relation to *both* higher education and government research. The links between public R&D and business R&D are also strong. All have a contribution of national R&D to GDP above 3%, which is associated with higher proportions of business research in the national research effort.

The causal relationships between institutional arrangements for funding public research, and specifically higher education research, national R&D performance, productivity improvement, and economic growth are unclear. It is not simply an issue of providing more money for research—it is a matter of allocating the resources available efficiently *and* effectively and ensuring that the whole system works in concert. However, what is clear based on the investigations for this study is that institutions do matter.

Thus, while the Study specifically focuses on higher education research, it is mindful of the role and contribution of government research in the public research system. This is particularly important when looking at research systems in Germany, Korea, and the USA.

In these respects, a potential re-alignment of Australian institutions with responsibilities for higher education research should, desirably, be approached within a broader context of public research investment arrangements. This is clearly outside the scope of this project.

It is nonetheless informative to look to other countries and identify aspects of their arrangements for higher education research that could be more closely connected to government research and the overall public research system, and that could work in an Australian context. Some thoughts on potential arrangements are provided in Addendum 2, starting on page 61.

Observations and recommendations relating specifically to higher education research are set out in the main body of the Report.

[3] Israel has a very large business R&D component in total R&D, of which over 50% is funded from overseas.

Executive Summary

This report compares the institutional settings of research systems in several "benchmark" countries: Canada, Germany, Israel, the USA and the UK.

Australia has a research system where much of the "heavy lifting" appears to be undertaken by the higher education system.

Higher education research is increasing while business investment in R&D has been falling, and government investment in R&D has been sluggish.

Exhorting businesses to invest more in R&D is of little use in the current institutional settings. The absence of global research-intensive companies that base their research capability in Australia is a major obstacle to the capacity to increase business R&D. CSL is the only global research-intensive business with an operating base in Australia.

There are no research-intensive global motor vehicle, technology, or pharmaceutical corporations with an R&D presence in Australia. Apart from CSL, Australia's largest R&D performers are Aristocrat and Fortescue Mining.

Small to medium companies are making commitments to R&D and are working closely with universities in experimental development. Venture-backed startups rarely invest in R&D—they tend to rely on R&D undertaken in universities and public research organisations. Therein lies a major challenge for Australia—to commercialise the R&D being created in these public organisations—not only to startups but also to large innovation-driven corporations that have a major commitment to external innovation sourcing.

Universities, together with state governments, are responding by working to attract global investors through investments in leading-edge research facilities.

Like universities around the world, these investments are being delivered through innovative financing arrangements, including structured finance and public-private partnerships, in addition to utilising retained earnings and borrowing.

The larger universities have been able to leverage their strong balance sheets, high credit ratings, and participation in innovation districts and precincts where their activities are associated with urban development and renewal.

This option is not available to all universities, particularly those located outside metropolitan areas. A system failure may occur if smaller regional universities cannot access the funds to enable their participation in a growing and vibrant university research system.

The Australian research system is heavily biased towards life sciences research. This is good for national human health outcomes and global rankings. However, there are downside aspects in a broader research system context.

The system requires a greater recognition of the critical roles of information and computing sciences and engineering research as the economy transforms to new industry structures. This requires both funding, specifically designated university linked research institutes, and research infrastructure in these areas.

Australia's research environment compared

Research investment

Most countries run large, ongoing investment programs supported by strong and stable institutional settings (programs listed on page 28). Many have been in operation for quite some time.

Australia's programs tend to be short-term "funding programs" that change with frequent alterations in the Administrative Arrangements Order, particularly after a change of government and a Ministerial reshuffle—which had been occurring with increasing frequency over the last two decades.[4]

Over the last few years, Commonwealth research funding has been shifting from higher education to other agencies that provide specific purposes.[5]

Frequent changes in administrative arrangements, terms, conditions, and eligibility for research funding have made the Australian research system unstable, with little opportunity to build resilience in institutional capacities and abilities.

This contrasts with Germany's system of formal processes, rules, and directives, which provides considerable stability to the administrative arrangements. The system is organised in a quasi-judicial fashion, which establishes continuity and increases the predictability of administrative and coordination processes[6].

Research delivery

Research delivery arrangements are highly fragmented across universities, national research institutes, CRCs, ARC Centres of Excellence, Departmental research laboratories, National Collaborative Research Infrastructure Strategy (NCRIS) supported facilities, and Departmental research divisions and bureaus.

While this is not of itself a problem, the system lacks coordination and leadership in the absence of a National Research Foundation or similar entity as established in other countries—

- Germany's Research Foundation was established in 1951 (with origins going back to 1920), and the National Research Foundation of Korea was established in 2009 (through a merger with several other agencies).
- The Israel Science Foundation was created in 1972.
- The US National Science Foundation was established in 1950.
- A UK equivalent, UK Research and Innovation, was created in 2018.
- A proposal for a Canada Research Foundation is under consideration following a review.
- Other countries with a national research foundation include—China (National Natural Science Foundation of China, established in 1986), Singapore (National Research Foundation Singapore, 2006), South Africa (National Research Foundation, 1999), and France (The French National Centre for Scientific Research, 1939).

In some countries, coordination and leadership are provided through designated research councils, while in others, the responsibility sits with a Ministry or Department or a number of Ministries/Departments, as is the case in Australia and Canada. Germany's Ministry of Education and Research also delivers a substantial research budget.

Based on the investigation and analysis undertaken for this report and the acknowledged issues concerning research investment and fragmentation in research delivery, there is a strong argument for establishing a National Research Foundation for Australia.

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[4] The Administrative Arrangements Order (AAO) specifies the names of departments of state, the principal matters they deal with, and the legislation administered within each Ministerial portfolio. In the United States, Administrative arrangements, including the formation of new Departments, must be endorsed by Congress.
[5] These include NHMRC investments for government research, Medical Research Institutes, and hospitals; other specific purpose research programs in health, rural R&D, energy, and environment. Some of these investments may find their way into university research activity—but often in a competitive tendering basis, where bidding is open to private research and international providers.
[6] Kuhlmann, S., Proeller, I., Schimanke, D., Ziekow, J. (2021). German Public Administration: Background and Key Issues. In: Kuhlmann, S., Proeller, I., Schimanke, D., Ziekow, J. (eds) Public Administration in Germany. Governance and Public Management. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-53697-8_1, p.66

Research output and impact

The data assembled for the project indicated that, internationally, Australia has comparatively very high levels of research output but a disappointing impact. While output is heavily concentrated in the life sciences, there is a long tail of comparatively small output levels across all FOR categories.

In several areas, while outputs are relatively small, performance is rated highly with international performance and impact metrics. This is particularly the case in information and computing sciences.

These observations suggest a need for greater concentration and scale in research efforts, rigidly defining scope—what Australia is good at or wants to be good at—and allocating resources accordingly.

Connections to the innovation system

International comparisons suggest that the Australian research system has strong connections to the broader innovation system. However, more attention could be given to supporting the role of innovation intermediaries and “system integrators” in innovation districts, hubs, and precincts.

1 Background and Context

1.1 Historical antecedents

The research systems in the seven countries in the Study reflect different aspects of the Newman and Humboldt philosophies of academic research and each country's socio-political culture.

Newman stressed the importance of a university as a community of scholars dedicated to pursuing knowledge for its own sake. In contrast, Humboldt emphasised the role of universities as *places* for research and discovery, practical applications, and a close connection between universities, industry, and the broader society.

Over time, the philosophies have become more integrated. However, Australia, Canada, and the UK still have strong elements of the Newman tradition, whereas Germany, Israel, and the US are steeped more in the Humboldt tradition. Nonetheless, different traditions are still reflected in institutional structures and frameworks.

The Study reveals that history is reflected in similarities between the Australian and Canadian research systems, while Korea and Israel reflect closely with the US system. Germany is almost unique in how it has built and sustained its research system around its distinctive socio-political culture over many hundreds of years[7].

1.2 What *is* the National Research System (NRS)

In Australia, reference is often made to the *Science, Research, and Innovation* (SRI) System. The Commonwealth Government publishes annual budget expenditure tables with this reference.

While reference is often made to an all-encompassing National Innovation System, it can be useful to unpack the different but interactive features of science, research, and innovation activity. Differences can be semantic, but it is useful to address the scope and coverage of a national research system broader than science and innovation.

The *National Research System* (NRS) is essentially an institutional concept—

The *National Research System* (NRS)
The network of institutions, organisations, and people within a country that are involved in creating new knowledge and improving existing knowledge to understand phenomena, solve problems, improve policy and decision-making, and advance science and innovation. The network includes universities, research institutes, government agencies, non-governmental organisations, and private sector entities conducting research across various fields.

Research policy is particularly interested in building institutional capabilities and people's abilities to undertake and deliver high-quality research.

The NRS is often taken to mean the *National Science and Research System* which has a specific connection to undertaking *Research and Development* (R&D). Some agencies go further and refer to *Research, Development and Extension*, which gives a focus on knowledge transfer for application and use.

[7] These observations are drawn from the Study and some knowledge of the traditions undertaken through prior research. A more in-depth and contemporary scholarly inquiry is something for another occasion.

The NRS is concerned with advances in knowledge not only in the fields of science and technology *but also* in the social sciences, humanities, and arts (HASS). It also encompasses a wider range of research activities and institutions that may not necessarily be directly connected to government policies and strategies.

The *National Innovation System* (NIS) encompasses the broader ecosystem of innovation that covers R&D *and* technology and knowledge transfer, research commercialisation, and innovation and entrepreneurship.

The NIS also encompasses the regulatory and legal frameworks, financial and investment mechanisms, and cultural and social norms that influence innovation and entrepreneurship. It also includes policies and strategies related to intellectual property rights, venture capital funding, innovation clusters, and other forms of Public-Private Partnerships that promote innovation and entrepreneurship.

1.3 Research investment policy and strategy

The scale and scope of R&D differs markedly across the countries in the Study: In 2020 The US had a total spend of $US664.1 billion—a thirty-fold difference from Australia.

A second tier is Germany ($US125.6 billion) and Korea ($US103.1 billion) and the UK ($US51.2 billion); a third tier is constituted by Canada ($US30.3 billion) and Australia ($US21.7 billion); and a fourth tier covers Israel ($US17.1 billion)—of which 49.5% is funded from overseas[8].

There is a strong view that Australia must spend more on R&D—an increase from the current 1.8% of GDP to 3.0% is often touted—an increase of two-thirds. However, it is not sufficient to argue that Australia must spend more on R&D—it is necessary to argue how such an increase would be allocated in the context of new and revised policies, programs, and delivery frameworks that are fit for purpose.

A policy to substantially increase the national R&D effort raises a question of "absorptive capacity". The currently fragmented framework of institutions and organisations is unlikely to deliver such a massive increase in resources and expectations. Innovative and transformational institutional frameworks would be required. In this context, it is helpful to look overseas, particularly in countries where the level of investment is significantly higher than in Australia.

This issue is particularly important for Australia, where a substantial proportion of the national research effort is being carried out by higher education institutions.

Many countries have developed or are developing national research strategies, often in concert with science and innovation strategies. They are either all-encompassing or sector-specific.

- Germany's Federal Ministry of Education and Research has also been realigning its research and innovation policy in a across all Ministries. It wants to "dare more progress in order to strengthen Germany's innovative power and secure Europe's technological sovereignty".
- In March 2023 the UK Government published the report of the Independent Review of the UK's Research, Development and Innovation Organisational Landscape, undertaken by Sir Paul Nurse. The analysis has many parallels with the situation with Australia.

[8] Unless otherwise stated, all comparative data is sourced from the OECD Research and Development Statistics and expressed in 2015 $US—Constant prices and Purchasing Power Parity (PPPs)

1.4 Research system institutional complexity

The research systems in each country are highly complex, with multiple organisations with varying roles and responsibilities for decision-making relating to resource allocation, research delivery, quality, coordination, and control. There are also complex interfaces between the science and engineering systems and the innovation systems.

In all countries in the Study research investment is coordinated, and to some extent controlled in ministries and departments that have terms like science, technology, research and/or innovation in their designations. Generally, there are multiple ministries and departments involved, particularly where there are separate agencies for health and the environment.

Countries have created complex public administration machinery that includes different combinations of—

- Ministries and departments
- Research councils
- National research foundations
- Research infrastructure investment bodies
- Advisory councils and committees
- Research intermediary organisations
- Organisations that promote university-industry collaboration
- Recognised higher education representative and advocacy organisations
- Regulatory and accreditation frameworks

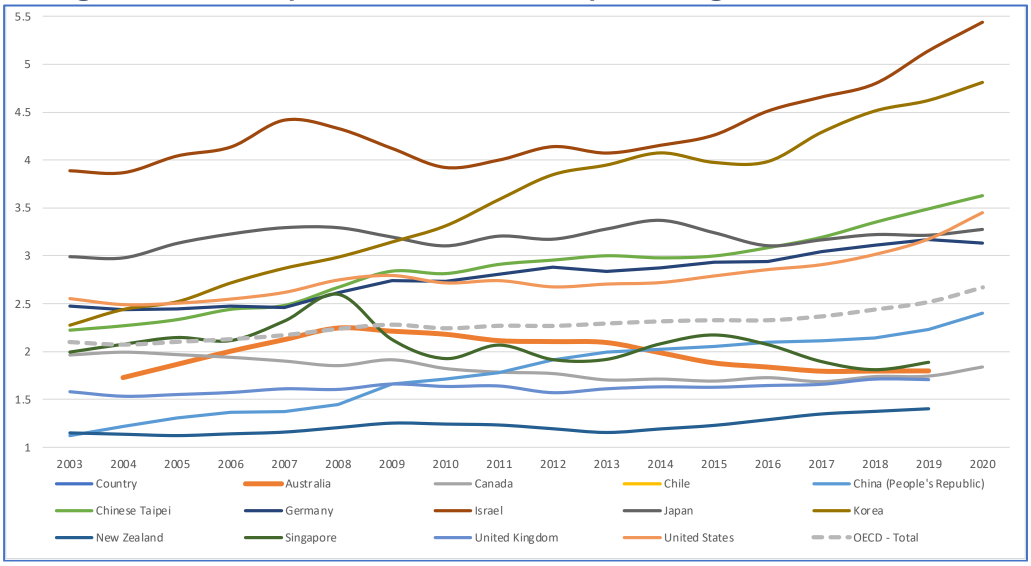
No countries in the Study have an independent body responsible for coordinating science, research, and innovation (SRI) strategy and resource allocation. SRI systems may be too big in terms of both resources and administrative complexity to develop one "grand plan". The UK Research and Innovation initiative may close, but time will tell.

It may be better to concentrate on each system dimension, such as research, and look for interfaces between the science and innovation dimensions.

1.5 National investment in R&D

Australia performs poorly in terms of the proportion of R&D expenditure in GDP. Comparisons with the Study countries are shown in Figure 1. Australia is represented by the thick orange line at the bottom, trending down since 2012.

Figure 1: Gross Expenditure on R&D as a percentage of GDP 2003-2020

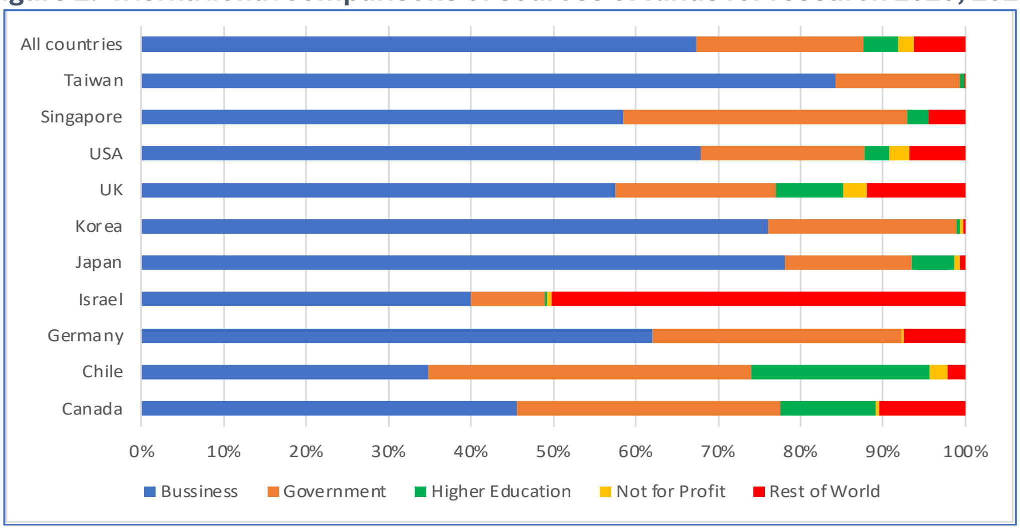


Source: OECD, Gross domestic spending on R&D, https://data.oecd.org/rd/gross-domestic-spending-on-r-d.htm

The OECD estimates that in 2020, 2021 for the countries included in the Study, together with other competitor countries (and where data is available), 67.8% of research and development funds were sourced from the business sector, 20.7% from government, 2.5% from higher education, 6.5% from the rest of the world, and 1.8% from the private, not-for-profit sector.

These estimates are represented in Figure 2. The OECD has not published data for Australia, although it is known that the Australian higher education sector contributes a significant proportion of general university funds to R&D investments. In Canada, the contribution of higher education to the national research effort is 11.6%, and in the UK, it is 8.1%. The Australian proportion is higher, but it is uncertain by how much.

Figure 2: International comparisons of sources of funds for research 2020, 2021



Source: OECD, Gross domestic expenditure on R&D by sector of performance and source of funds.

These estimates do not include non-current funding sources to finance capital investments in research facilities, such as borrowing, leveraged finance, and Public-Private Partnership arrangements. These sources have been increasing and are now quite substantial as universities leverage their balance sheets and credit ratings to finance major building projects[9]. This is discussed in more detail in Section 4.5 on page 36.

On the expenditure side, OECD data indicates that for the countries included in the Study and other competitor countries, the business sector contributes 76.1% of national expenditure on R&D, higher education 10.6%, government 11.2%, and the not-for-profit sector 1.8%.

[9] See Kasia Lundy, Haven Ladd, Ernst & Young, How the right public-private partnerships in higher education provide value, 2021. The authors report that in 2016 there were 28 PPPs in Australian higher education with a value of $3.1 billion. They note "There has been approximately a 50% year–over–year increase in the value of the P3 transactions, and some speculate that the volume may reach $5b over the next five years".

2 Comparative Analysis of the Governance and Operations of National Research Funding Systems

The research systems in each country are highly complex, with multiple organisations with varying roles and responsibilities for decision-making relating to resource allocation, research delivery, quality, and accountability. There are also complex interfaces between the science and engineering systems and the innovation systems.

Countries included in the Study adopt a range of institutional arrangements for research investment vehicles to establish national strategies, allocate resources, and secure accountability. It does not appear to be a matter of a prescriptive "one size fits all" but creating a framework that is fit for purpose. New frameworks have come out of recent reviews and enquiries.

2.1 Institutional settings

Research systems range from Germany's highly organised style to Australia's highly fragmented "laissez-faire" style. Below is a profile of each system.

2.1.1 Canada

Table 1: Canada's National Public Research System

Organisations	Comment
National oversight	Innovation, Science, and Economic Development Canada.
Advisory Councils	Council of Ministers of Education, Canada (CMEC) Office of the Chief Science Adviser Council of Ministers of Education, Canada (CMEC) Canada Research Coordinating Committee A recent proposal from the Advisory Panel on the Federal support system for an independent Advisory Panel
Research investors	Three Ministries with significant research investment programs; Agriculture and Agri-Food Canada, Natural Resources Canada, Health Canada The Tri-Agency Councils: the Canadian Institutes of Health Research (CIHR) – 13 Institutes, the Natural Sciences and Engineering Research Council (NSERC), the Social Sciences and Humanities Research Council (SSHRC) Application and criteria-driven research (and innovation) funds: Canada First Research Excellence Fund, Strategic Innovation Fund, Canada Research Chairs, Research Support Fund (RSF) A recent proposal for a Canadian Knowledge and Science Foundation prepared by the Advisory Panel on the Federal support system is currently with the Minister
Universities	Canada has 223 public and private universities, and 213 public colleges and institutes
National Institutes	National Research Council of Canada – The primary national agency dedicated to science and technology research & development. It is the largest federal research & development organisation in Canada
Departmental Research Institutes	Federal government agencies have numerous research institutes conducting scientific research in support of a larger mandate: Agriculture and Agri-Food Canada Canadian Food Inspection Agency Canadian Grain Commission Canadian Polar Commission Communications Security Establishment

	Environment Canada Fisheries and Oceans Canada Natural Resources Canada
Medical Research Institutes	There appear to be 16 Medical Research Institutes in Canada
Public Research Organisations	Atomic Energy of Canada Limited - Ottawa, Ontario Canadian Space Agency Defence Research and Development Canada

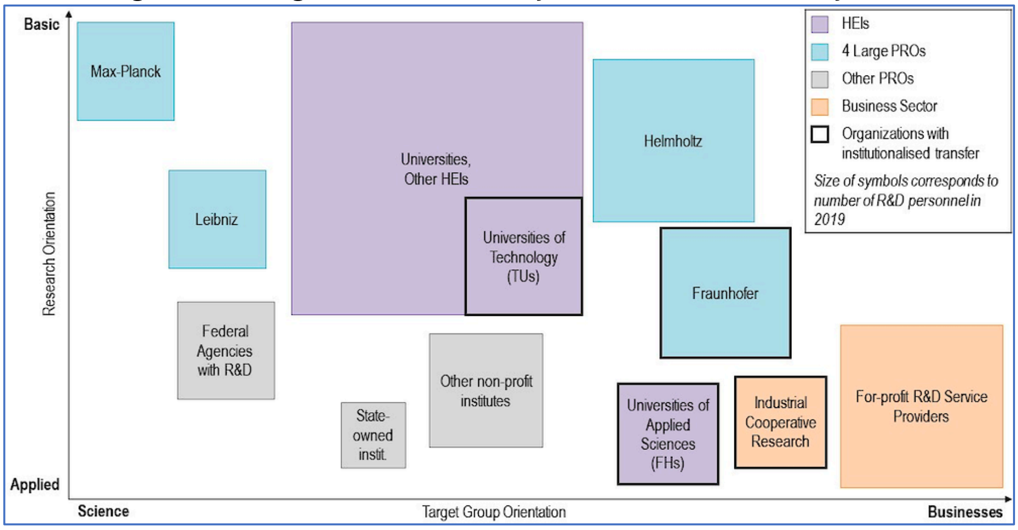
2.1.2 Germany

Table 2: Germany's National Public Research System

Organisations	Comment
National oversight	Federal Ministry of Education and Research (BMBF) Federal Ministry for Economic Affairs and Climate Action (BMWK)
Advisory Councils	National Academy of Sciences Leopolinda
Research Investors	Federal Ministry of Education and Research (BMBF) funds applied research projects, particularly in areas of strategic importance to Germany such as energy, health, and mobility. The German Research Foundation (DFG). Endowed by the federal (69%) and state (30%) governments. In 2021, the DFG funded more than 31,600 new and ongoing projects with a funding volume of €3.6 billion. It funds basic research projects in all disciplines, establishment of research groups, priority programs, and collaborative research centres. Federal Ministry for Economic Affairs and Energy (BMWi) supports research and development in emerging areas such as artificial intelligence (AI), blockchain, and the Internet of Things (IoT) Germany Trade and Invest (GTAI). The economic development agency of the Federal Republic of Germany. It supports export promotion, recruits, and advises foreign investors, and strengthens the image of Germany as a business location and promote the new federal states.
Universities	456 universities, including 112 General universities (including 20 Technology Universities), 236 Universities of applied sciences, and 108 colleges. Twenty general universities focus on engineering and technical sciences.
Research societies and associations	The *Fraunhofer* Society—76 institutes that focus primarily on applied research; The *Helmholtz Association*—18 centres that operate research infrastructures – including accelerators, telescopes, research vessels and super computers; The *Leibniz* Association—acts as an umbrella for 100 research institutions investigating scientific and societal problems. The *Max Planck Society*—84 institutes and facilities that focus primarily on basic research.
Government Laboratories	In addition, the Federal Government operates 42 Government laboratories. Significant laboratories include— The *Robert Koch Institute* (RKI) in Berlin, is responsible for disease control and prevention. The *Federal Institute for Materials Research and Testing* (BAM) is responsible for increasing safety and reliability in chemistry and materials technologies, including statutory regulations on safety standards and threshold values. *Deutsches Elektronen-Synchrotron* (DESY). One of the world's leading accelerator centres.
Medical Research Institutes	38 Medical Research Institutes in Germany
Collaborative Research Centres	The DFG currently funds 279 Centres with a total of €848 million. Collaborative Research Centres are long term university-based research institutions, established for up to 12 years.

The configuration of Germany's National Research system is represented in Figure 3.

Figure 3: Configuration of Germany's National Research System



Source: The German research base for innovation, OECD Library

Germany's public research organisation structure stands out in sharp contrast to many other countries. It is intensive, highly organised, centrally directed and "rational".

2.1.3 Israel

Table 3: Israel's National Public Research System

Organisations	Comment
National oversight	The Ministry of Innovation, Science and Technology The Chief Scientist
Advisory Councils	National Research Council of Science and Technology
Research Investors	The Israel Science Foundation (ISF) Binational Industrial Research and Development (BIRD) Foundation
Universities	Ten universities and 53 colleges
Medical Research Institutes	There appear to be two medical research Institutes in Israel
Note:	Israel appears to have a less complex research system than others in the Study. Israel spends a similar amount on R&D to Australia. In 2019 Israel spent $US18.52 (2019), and Australia $US21.74 billion (2019). Israel's population is 9.4 million, and Australia's is 25.7m. Australian comparable figures are not available for 2021 (or 2020). But in Israel, 90.4% of R&D expenditure is by business, while in Australia, it is 51.4%. Also, 53.2% of Israel's R&D is financed from overseas sources. These considerations would make the Israel system much less complex, and less comparable with other research systems.

2.1.4 Korea

Table 4: Korea's National Public Research System

Organisations	Comment
National oversight	Ministry of Science and ICT
Advisory Councils	Presidential Advisory Council on Science and Technology (PACST) National Research Council of Science and Technology (NST)
Research Investors	National Science Foundation of Korea (NRF) The Ministry of Science and ICT (MSIT),

Organisations	Comment
	The Ministry of Trade, Industry, and Energy (MOTIE)
Universities	190 universities, 134 junior colleges, 45 graduate schools.
National Institutes	Korea Institute of Science and Technology. Established in 1966 by the Korean and US governments to be the first comprehensive research agency for the promotion of the nation's economic growth and the modernisation of engineering fields. The Korea Electrotechnology Research Institute is non-profit government-funded research institute. Korea Institute of Energy Research. Commitment to establish a Bio foundry
Medical Research Institutes	None identified

2.1.5 United Kingdom

Table 5: The UK's National Public Research System

Organisations	Comment
National oversight	Department for Science, Innovation and Technology (DSIT)
Advisory Councils	Council for Science and Technology (CST) Industrial Strategy Council
Research Investors	Nine research councils under UK Research and Innovation (UKRI)- a non-departmental public body sponsored by DSTI: Arts and Humanities Research Council (AHRC), Biotechnology and Biological Sciences Research Council (BBSRC), Engineering and Physical Sciences Research Council (EPSRC), Economic and Social Research Council (ESRC), Medical Research Council (MRC), Natural Environment Research Council (NERC), Research England – funds and engages with English higher education providers (HEPs). Science and Technology Facilities Council (STFC) National Institute for Health and Care Research (NIHR) - the UK's largest funder of health and care research. Research Funds: Research Capital Investment Fund, Expanding Excellence in England Fund, International Investment Initiative, Research England Development Fund, UK Research Partnership Investment Fund The Advanced Research and Invention Agency (ARIA) a new agency that will support high-risk, high payoff research.
Universities	164 universities and higher education institutions.
Public Science Research Entities (PSREs)	50 public research entities, including those sponsored by the devolved administrations. They include: Defence Science and Technology Laboratory HSC Innovations Joint Nature Conservation Committee (JNCC) The Met Office National Engineering Laboratory National Nuclear Laboratory National Physical Laboratory Natural Resources Wales (Cyfoeth Naturiol Cymru) Scottish Health Innovations UK Atomic Energy Authority
Research Infrastructures	500 nationally and internationally significant investments in “research infrastructures” (facilities, resources and services used by the research community to conduct research and foster innovation.).

Organisations	Comment
	75% of these work with businesses and generate clusters of private businesses[10]. RIs are focus points for innovation: the Fusion Energy RIs have led to significant advances in robotics and remote handling and the ISIS Neutron Source is testing advanced materials for jet engine turbines.
Medical Research Institutes	There are five Medical Research Institutes that receive funding from the Medical Research Council.

The Science and Technology Facilities Council plays a major role in building this capability.

2.1.6 USA

Table 6: The USA National Public Research System

Organisations	Comment
National oversight	Office of Science and Technology Policy The House Science, Space, and Technology Committee Senate Committee on Commerce, Science and Transportation, Sub-Committee on Space and Science
Advisory Councils	National Science and Technology Council
Research Investors	National Science Foundation, established 1950. National Institutes for Health (NIH) National Institute of Standards and Technology (NIST) Department of Energy (DOE) Department of Defense (DOD) – Basic Research Directorate Department of Agriculture (USDA)
Universities	3,939 higher education institutions: 279 Doctoral high or very high research activity universities 189 Doctoral/ professional universities 667 Master's Colleges and Universities 734 Baccalaureate Colleges 948 Associate Colleges 340 Special Focus 2-year colleges 501 Special Focus 4-year colleges 35 Tribal Colleges and universities
Government Research Laboratories	The US funds a system of between 80 and 100 government research laboratories that conduct scientific research and development related to energy and technology. They emerged during WWII and have served as the leading institutions for scientific innovation for 70 years. For the most part, the labs are funded to help agencies achieve their missions[11]. DARPA and ARPA-E, while not part of the laboratories system, have played an important role in developing cutting edge technologies.
National Science Foundation (NSF) supported Engineering Research Centres (ERC)	established in 1985 to support convergent research, education, and technology translation at US universities.
Medical Research Institutes	There are 91 identified medical research institutes in the US.

[10] An example is the Harwell Science and Innovation Campus formed in 1946 in Oxfordshire to tackle the energy crisis, it now has over 240 public and private sector organisations, working across sectors including Space, Clean Energy, Life Sciences and Quantum Computing.

[11] They include Ames Laboratory, Argonne National Laboratory, Brookhaven National Laboratory, Fermi National Accelerator Laboratory, Frederick National Laboratory for Cancer Research, Idaho National Laboratory, Lawrence Berkeley National Laboratory, Lawrence Livermore National Laboratory, Los Alamos National Laboratory, National Energy Technology Laboratory, National Renewable Energy Laboratory, Oak Ridge National Laboratory, Pacific Northwest National Laboratory Princeton Plasma Physics Laboratory, Sandia National Laboratory, Savannah River National Laboratory, SLAC National Accelerator Laboratory, Thomas Jefferson National Accelerator Facility

Organisations	Comment

The *Chips and Sciences Act*, the *COMPETES Act*, and the *Inflation Reduction Act* have fundamentally changed the dynamics of the US Research System. The amounts are so large, and the role of the NSF is now so significant that there has been a centralisation in the resource allocation system.

2.1.7 Australia

Australia has an extensive portfolio of National Research Institutes, Public Research Organisations, Government Research Laboratories, and Departmental research capabilities, but overall, its investments are relatively small compared to those of the countries in the Study.

Table 7: Australia's National Public Research System

Organisations	Comment
National oversight	Department of Industry Science and Resources - science and commercialisation Department of Education – Research in higher education.
Advisory Councils	National Science and Technology Council Chief Scientist
Research Investors	Department of Education, Department of Industry Science and Resources Department of Agriculture, Department of Climate Change, Energy, The Environment and Water, Department of Defence, Department of Health Australian Research Council, National Health and Medical Research Council Rural Research and Development Statutory Corporations and Companies (15 in total) Research Funds: Medical Research Future Fund, Research Support Program Cooperative Research Centres Committee Australian Renewable Energy Agency (ARENA) National Collaborative Research Infrastructure Strategy (NCRIS)
Universities	170 higher education providers; 43 universities, 127 non-university higher education providers
National Institutes	CSIRO, ANSTO, DST, AIMS.
Medical Research Institutes	58 MRIs who are members of the Association of Australian Medical Research Institutes. The National Health and Medical Research Council (NHMRC) funds 99 entities, including MRIs, hospitals, and universities
Cooperative Research Centres (CRCs)	24 currently operating.
ARC Centres of Research Excellence	21 currently operating.
ARC Industrial Transformation Hubs	4 currently operating.
Departmental Research Laboratories	Including the Antarctic Division, Geoscience Australia.
NCRIS supported research facilities	Including the National Fabrication Facility, Australian National Insect Collection (ANIC), Australian Plant Phenomics Facility (APPF), Bioplatforms Australia, National Imaging Facility (NIF), AuScope, and many more.
National Research facilities operated by CSIRO	Including the Australian Centre for Disease Preparedness, formerly the Australian Animal Health Laboratories, The Australian Telescope National Facility, the National Marine Facility, the Pawsey Supercomputing Centre, the Canberra Deep Space Communication Complex.
ANSTO Australian Synchrotron	Operated by the Australian Synchrotron Research Program(a collaboration between ANSTO, CSIRO, and several other research organisations and universities).
Departmental Research Divisions and Bureaus	Resources allocated within departmental *"funding envelopes"* that serve Departmental missions.

Organisations	Comment
Quasi-autonomous university research institutes and centres[12]	Established with support from Government and industry. They include: The Institute for Frontier Materials (Deakin), Sustainable Materials Research & Technology Institute (UNSW), Australian Plant Phenomics Facility (Adelaide), The Heavy Ion Accelerator (ANU), Sydney Institute for Robotics and Intelligent Systems (Sydney), The Queensland Alliance for Agriculture and Food Innovation (Brisbane), The Newcastle institute for Energy Research NIER (Newcastle), The Quantum Academy (Sydney).

The configuration of Australia's research system appears to be highly fragmented. It can be represented as follows:

Figure 4: Configuration of Australia's National Public Research System

Source: Compiled by the Report authors

Notwithstanding the capability of the system, unlike Germany, Australia lacks a systematic framework for categorisation and resourcing of Government research organisations, laboratories, and research facilities. This could generate greater efficiency and effectiveness in the use of resources and contribute to enhanced research outcomes.

Conclusion

1. *In comparison with other countries, and particularly Germany, the UK and the USA, Australia lacks a framework of permanent cross-sectoral collaborative research institutes and laboratories that support long term research partnerships and collaborations between university, government, and industry. These frameworks have taken many years to create. Australia can achieve the many benefits of these frameworks by further developing the model of the "quasi-autonomous university research institute" established with strong support from Governments (Commonwealth and State) and industry to build long term and resilient university-industry research collaborations. Current applications of the model are at The Institute for Frontier Materials (Deakin), Sustainable Materials Research & Technology Institute (UNSW), the Queensland Alliance for Agriculture and Food Innovation (Brisbane) and the newly formed Sydney Quantum Academy.*

[12] With resources for Government research capability being increasingly constrained, the Australian Higher Education sector and state government agencies, and businesses have established a model of "quasi-autonomous university research institutes and centres" established with strong support from Government and industry. There is scope for further development of this model.

2.2 Research systems operate differently in unitary and federated countries

Of the seven countries included in the Study, four have a federal system of government where constitutional powers to make laws, operational responsibilities, and accountabilities are held by different levels of government (the USA, Germany, Canada, and Australia).

Three of the countries are unitary systems (Israel, Korea, and the UK) where a central government holds the power to make laws. The UK has a system of devolved responsibilities, where Scotland, Wales, and Northern Ireland undertake some research functions.

Even between federal systems, the distribution of constitutional powers varies. In Canada, Germany, and the US, State Governments exercise substantial powers over higher education teaching and learning, while responsibilities are shared in research. In Australia, teaching and learning became centralised when the Commonwealth took over funding for teaching and learning in 1973.

This gives the Australian Government substantial policy influence over the States and territories, notwithstanding that the States still retain responsibilities for universities under State legislation. The 1973 takeover did not specifically cover research functions.

Central policy coordination varies in Federations (US, Germany, Canada, and Australia), with German Lander having substantial involvement in funding and delivery and less so in Australia and Canada. The US is dominated by Federal funding and institutions, which will likely become more so with the *Chips and Sciences Act* and the *Inflation Reduction Act*.

Below is comparative information on institutional arrangements for the countries covered by the Study. Further information on operational arrangements and institutional frameworks specific to each country is provided in Section 5 below.

2.3 Research system policy coordination

No countries covered in the Study have independent bodies responsible for policy development and setting the resources to be allocated to higher education research—or higher education and research more generally.

- The Higher Education Funding Council for England (HEFCE) was abolished in 2018[13].
- The Australian Tertiary Education Commission was abolished in January 1990 and replaced with the National Board for Employment, Education and Training; then, the Australian Higher Education Council was subsequently “absorbed” into Universities Australia in 2008.
- California’s Post-Secondary Education Commission (CPEC) was vetoed by Governor Brown in 2011[14].
- The UK has embarked on a new model with UK Research and Innovation, established in 2021[15].
- New Zealand retains a Tertiary Education Commission (TEC).

Ministerial responsibility and accountability issues are involved in assigning policy and resource allocation roles to independent organisations. Under the Westminster system, Ministers will always be responsible and accountable to Parliament for the expenditure of

[13] With research functions taken up by Research England, a body under the umbrella of UK Research and Innovation.
[14] CPEC’s role was to ensure that fiscal and program policies were consistent with state goals, long-term planning for physical and program changes, and using data to monitor system performance. “But CPEC’s history suggests that a divided board hampered by a lack of clear state goals could not meet policymakers’ needs”(Paul Warren, Coordinating California’s Higher Education System, 2019.
[15] Governance arrangements are set out in the UKRI Framework Document which covers the relationship between UKRI and the Department for Business, Energy and Industrial Strategy.

public funds. However, they rely on various stakeholders for information, advice, and guidance. For example—

- Universities Australia, as a cross-sectoral organisation, retains a major role in coordinating the research system. Its submissions and recommendations are taken seriously by policymakers—if not always adopted.
- The Association of American Universities[16] seems to have a similar role. However, many other peak bodies also take on advocacy, representation, and lobbying roles.

Section 7 provides a more detailed analysis of the role of stakeholders in research systems.

In either or both cases, budgets and operational guidance would be endorsed by Ministers and authorised by national legislatures. The policy coordination body would provide important input into this process but would not direct or control it.

In the past, there has been some resistance to devolving research system resource allocation decision-making to independent research investment bodies. However, notwithstanding the independent operation of many national research investment bodies, central ministries and departments will still want to retain influence over resource allocation and strategic priorities. Concerns arise when this influence extends to political decisions over project funding.

2.4 The roles of Government agencies

2.4.1 Ministries and Departments

The research investment role of ministries and departments is strong in Australia, with the Departments of Education (University Research), Industry, Science and Resources (STEM), Health (Health, Biomedical and Clinical Sciences), Agriculture, Defence, and Climate Change, Energy, The Environment and Water.

Across these agencies, Ministers have recently announced funding programs to invest in research on cybersecurity, quantum technologies, renewable energy, and climate change.

There is no specific Australian Ministry or Department responsible for research in the Humanities, Arts and Social Sciences (HASS).

Capability in other countries includes:

- Germany: The Federal Ministry of Education and Research (BMBF) is a major research investor, with an Annual Budget of €20.8 billion (2021)
- Canada: The Ministry of Innovation, Science and Economic Development (which covers the National Research Council of Canada[17]), Agriculture and Agri-food Canada, with 22 research-connected programs; and Natural Resources Canada, with programs in Arctic science, climate change, cybersecurity, energy research, forest science, geomatics and geoscience, materials, natural hazards, space weather, and remote sensing.
- Korea: The Ministry of Science and ICT (MSIT) has a major role in funding research investment together with the Ministry of Trade, Industry, and Energy (MOTIE)
- USA: The Departments of Agriculture (USDA), Defence, and Energy are major research investors.

[16] AAU is an organisation of American research universities devoted to maintaining a strong system of academic research and education. Founded in 1900, it consists of 63 research universities (represented by their Presidents) in the USA and Canada. The organisation's primary purpose is "to provide a forum for the development and implementation of institutional and national policies to strengthen programs in academic research, scholarship, and education at the undergraduate, graduate, and professional levels". It (and similar organisations) is frequently consulted by the NSF, for example, on issues related to science policy and funding priorities.

[17] An organisation like CSIRO—not to be confused with the tri-agency research councils.

Ministry investment programs, particularly for applied research, can ensure resources flow to areas of national strategic importance—such as manufacturing, technology, energy, and health.

2.4.2 Research investment councils

Australia has two principal research investment councils: the Australian Research Council and the National Health and Medical Research Council. The Council of Rural RDCs does not decide on research investments. Other countries focus more on investment through research councils.

- Canada has a "Tri-Agency" model with the Canadian Institutes of Health (13 Institutes), the Natural Sciences and Engineering Research Council (NSERC), and the Social Sciences and Humanities Research Council (SSHRC).

Canada's Tri-Agency model

The Canadian research Councils collaborate on major cross sector research programs, including Canada Research Chairs Program and the long running Canada First Research Excellence Fund, and the New Frontiers in Research Fund where funding has averaged $US148m annually since 2015.

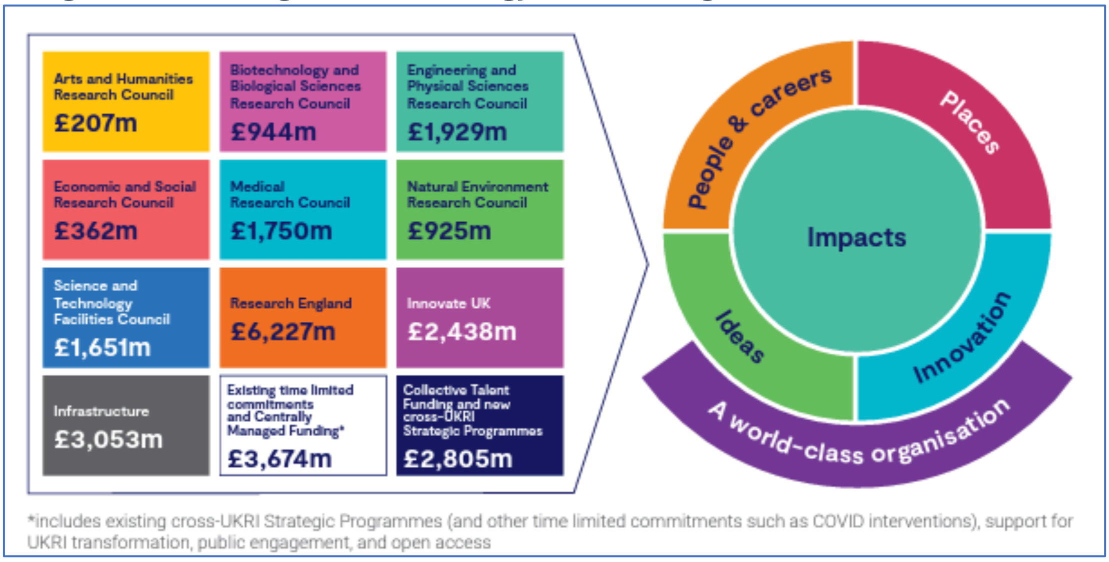
The framework outlines the principles and guidelines for supporting and promoting research excellence in Canada across a wide range of disciplines, including guidelines and policies for awarding research grants and scholarships, ensuring a rigorous peer review process, research ethics, knowledge dissemination, collaboration and adoption, equity, and inclusion.

Unlike the UK there is not an oversight body for the Councils.

Created under legislation, the Councils report to Parliament through the Minister for Innovation, Science, and Economic Development.

- The UK goes further with nine research Councils under the umbrella of UK Research and Innovation (UKRI), a non-departmental public body sponsored by DSTI. Funding allocations for 2022-23 – 2024-25 are shown in Figure 5.

Figure 5: Delivering the UKRI Strategy: total funding allocations, 2022-23 – 2024-25



Source: UKRI Budget 2022-25 Allocations

Germany has established a Research Council with specific responsibility for the national industry strategy Plattform Industrie 4.0. The Council independently advises the Plattform, its working groups, and the German federal ministries, particularly the Ministry of Economic Affairs and Climate Action and the Ministry of Education and Research.

2.4.3 National research foundations

In many countries, research investment occurs through a national research foundation. Below are profiles of counties that have these arrangements.

- Germany: The German Research Foundation (DFG) is the central self-governing research funding organisation in Germany. Its focus is on funding projects developed by the academic community itself in knowledge-driven research. The DFG has a current annual budget of €3.6 billion, provided primarily by the German Federal Government (69 per cent) and the states (30 per cent) but also includes EU funds and private donations[18].
- Canada: In March 2023, the Advisory Panel on the Federal Research Support System recommended the creation of a *Canadian Knowledge and Science Foundation*.

Proposal for Canadian Knowledge and Science Foundation

It is clear to the panel that the granting councils have a strong reputation of excellence in their support of investigator-initiated research in specific disciplines and training of talent. They should be commended and better supported for this foundational role.

The panel is strongly supportive of retaining and strengthening this role for the councils. Based on the input received by the panel, there is also a need for a new, complementary governance mechanism to work alongside the existing system, with a clear division of responsibilities between it and the councils. This new governance mechanism would be designed to better support coordination and encourage urgent, international, multi-, and interdisciplinary and mission driven research in Canada.

The *Canadian Knowledge and Science Foundation* (CKSF) would foster collaboration across the system to support urgent, multi-, and interdisciplinary, mission driven research to help address pressing social, technological, economic and health challenges.

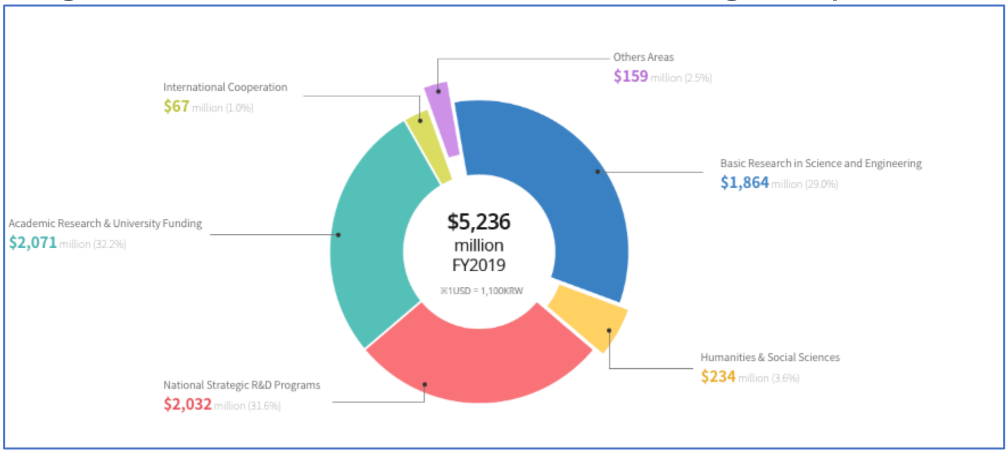
The CKSF would also improve support for the talent continuum through greater coordination of programming. It would be designed to rapidly coalesce the research community across all sectors around missions that could be cross cutting, interdisciplinary and high-risk..

https://ised-isde.canada.ca/site/panel-federal-research-support/en/report-advisory-panel-federal-research-support-system#23

- Israel: The Israel Science Foundation is the major organisation supporting basic research in Israel. The Israel Academy of Sciences and Humanities administers it. Its annual budget is $US142m. The majority of ISF funding comes from the Government of Israel.
- Korea: The National Research Foundation of Korea was launched in 2009 as a representative organisation specialising in research management in Korea. The NRFK plans, evaluates, and manages all projects related to academic and R&D activities of universities, research institutes and industries covering all humanities, social sciences, and engineering areas. The 2019 budget amounted to $US5.24 billion.

[18] This funding model differs from all other Foundations in that it involves State Governments as co-investors.

Figure 6: Korea National Research Foundation—budget components, 2019



Source: [KNRF]

- US: Congress established the National Science Foundation in 1950 to promote the progress of science, advance national health, prosperity, and welfare, and secure national defence. Its investments account for about 25% of federal support to America's colleges and universities for basic research. The proposed 2024 Budget is for $11.314 billion, an increase of 18.6% from the agency’s current budget.

The investigations for this Study suggest that National Research Foundations have had a significant role in driving economic development and growth through clear strategies and allocation of substantial research investments.

While the creation of an Australian National Research Foundation, building on the models of Germany, Israel, Korea, and the US, would be an attractive option for Australia's research and innovation-led growth, the process could be disruptive, involving major changes to the existing research investment infrastructure, but potentially capable of delivering transformational change in the research and innovation systems.

In this context, a commitment to the formation of a National Research Foundation for Australia would require much more detailed consideration.

2.4.4 Investment in research facilities and equipment

Through their Foundations and Councils, Germany, the UK and the USA make major commitments to research infrastructure—facilities, and equipment.

- Australia’s investment is more modest and dispersed, having abolished the Education Investment Fund. Infrastructure investment is supported by one-off grants and many smaller funding programs, including the National Collaborative Research Infrastructure Strategy (NCRIS).
- Larger universities tend to invest in their own infrastructure by retaining earnings and borrowings. However, this option is unavailable to smaller regional universities and public research organisations operating within the Commonwealth budgetary framework.
- University researchers seek access to research facilities in Australia and a broader range of facilities internationally. However, the cost of access can be a major impediment.

University access to national research facilities and equipment

The cost of accessing major national research facilities varies depending on the facility, the type of research being conducted, and the funding sources available to the university or research team. The cost of access can be substantial, as they require specialised equipment and highly trained personnel to operate and maintain.

Some facilities offer subsidised or discounted rates for academic users, while others may require full-cost recovery.

Overseas facilities are generally open for international scientists. This is an option for Australian researchers where facilities are unavailable, but the cost may be prohibitive when considering international travel and associated costs. Information regarding access costs and user fees for a sample of facilities is provided in Table 8.

Table 8: Costs of access to major research facilities in Australia and Internationally

Country	Facility	User Fee Range
Australia	Australian Synchrotron	$US475 to $US2,060 per day
	Australian Centre for Neutron Scattering (ACNS)	$US325 to $US2,160 per day
	National Imaging Facility (NIF)	$US78 to $US390 per hour
	Australian National Fabrication Facility (ANFF)	$US62 to $US2,350 per hour
	Centre for Accelerator Science	$US610 per hour
	National Deuteration Facility	$US360 per gram
Canada	Canadian Light Source —Soft X-ray Microcharacterization Beamline — Hard X-ray Microcharacterization Beamline	 $US187 to $US556 per hour $US187 to $US470 per hour
	Canadian Nuclear Laboratories (CNL) (Whiteshell Laboratories)	$US1,600 to $US4,000 per day
	Canadian Centre for Electron Microscopy (CCEM) — Titan 80-300 Transmission Electron Microscope —Aquilos Cryo-FIB/SEM: User fees range from.	 $US384 to $US576 per hour. $US672 to $US1,344 per hour
	TRIMF Cyclotron Facilities	$US1,200 to $US4,000 per day
Germany	BESSY II synchrotron radiation facility	$US990 to $US1,690 per day
	BER II neutron source	$US180 to $US1,440 per day
	PETRA III synchrotron radiation facility	$US590 to $US2,360 per day
	Wendelstein 7-X stellarator	$US720 to $US2,880 per day
	Jülich Centre for Neutron Science (JCNS)	$US590 to $US1,770 per day
Israel	Israeli Centre for Electron Microscopy (ICEM): User fees range from	$US123 to $US462 per hour
	National Nanotechnology Infrastructure Network (NNIN)	$US93 to $US1,240 per hour
	Israeli National Centre for High-Resolution Electron Microscopy (I-NCHARM)	$US123 to $US370 per hour
Korea	Institute of Science and Technology (KIST) Facilities: User fees range from	$US130 to $US870 per day
	Korea Research Institute of Standards and Science (KRISS) Facilities (including the Pohang Light Source (PLS)	$US173 to $US1,040 per day
	Korea Research Institute of Chemical Technology (KRICT) Facilities	$US86 to $US430 per day
UK	ISIS Neutron and Muon Source: User fees range from.	$US68 to $US2,040 per day
	Central Laser Facility: User fees range from	$US840 to $US3,080 per day
	Diamond Light Source: User fees range from	$US1,440 to $US5,000 per day
USA	National High Magnetic Field Laboratory (NHMFL)	$US190 to $US760 per hour
	National Synchrotron Light Source II	$US120 to $US4,200 per day
	Advanced Photon Source: User fees range from	$US200 to $US5,000 per day
	High-Flux Solar Simulator	$US3,000 to $US6,000 per day
	High-Flux Isotope Reactor	$US1,500 to $US4,500
	Spallation Neutron Source	$US4,500 to $US10,000

Source: Internet searches.

The information in Table 8 has not been validated with each facility.

2.4.5 Revenue agencies

Agencies charged with administering the corporate tax system are major players in the framework of institutional roles and responsibilities, particularly regarding R&D tax credits.

2.5 Advisory councils and committees

Advisory councils and committees are important in setting policy and resource allocation frameworks for Research Investment. Formats and roles vary across countries. They include:

- Australia: The National Science and Technology Council advises the Prime Minister and other Ministers on important science and technology issues facing Australia. The Chief Scientist provides strategic advice by leading and participating in several key priority bodies, including The National Science and Technology Council, Industry Innovation and Science Australia, the Forum of Chief Scientists, the Government Scientists Group, the National Data Advisory Council, and the National Climate Change Authority Board.

- Canada: The Chief Science Adviser provides advice on science-related issues and government policies, including ensuring that scientific knowledge is considered in public policy decisions and that government science is fully available.

  The report from its Advisory Panel on the Federal Research Support System recommended the creation of an independent advisory body to provide the government with strategic policy advice on science, research and innovation and evaluate and publicly report on the support for and performance of these activities in Canada.

  Advisory Panel on the Federal Research Support System: Proposal for an Independent Advisory Panel

  This body would also play a key role in setting a vision for the future, shaping Canada's longer-term science, research and innovation priorities and an ambitious, multi-year national strategy to achieve them. It is expected that the strategic plans for the CKSF and individual funding organisations would seek to align with the national strategy. In addition to research and innovation expertise, we recommend that the membership of the proposed advisory body include representation of the Indigenous research community, as well as other equity-seeking and rights-holding groups to encourage diversity across the research and innovation ecosystem.

  The advisory body would provide guidance to the government on the priorities of a national science, research, and innovation strategy, with the support of the science, research, and innovation community.

  A strategic advisory capacity and national strategy for science, research and innovation would provide a coherent, focused, and long term approach to advancing Canadian research success (from investigator-initiated curiosity-driven research to interdisciplinary and/or mission driven research), and would signal to our global peers that Canada is serious about research and innovation and is a worthy partner

- Germany: The National Academy of Sciences Leopolinda—The Leopoldina, in cooperation with other national and international organisations, is responsible for identifying and analysing scientific issues of social importance. It scientifically reviews and addresses key issues of prospective significance for society. Its findings are conveyed to policymakers and the public and advocated nationally and internationally.

- Israel: The National Research Council of Science and Technology—a role that examines Israel's existing research and development systems and maps their needs and points of strength and weakness. The Council recommends national policy to the Government on subjects related to research and development, produces reports, and conducts surveys on the status of science and research in Israel as a tool to achieve national goals. The Council is comprised of 15 professionals from fields related to academia, industry, and government policy.

- Korea: The Presidential Advisory Council on Science and Technology (PACST)—provides advice to the President regarding "the innovation of national science and technology", strategies for the development of personnel, information and policy, the improvement of systems, and matters regarding policies. The Council also has a deliberative role in relation to major science, technology and innovation policies, industrialisation-related personnel policies, and innovation policies for regional technology and research and development plans.

- UK: The CST advises the Prime Minister on government science and technology policy issues.

- US: The US National Science and Technology Council—a cabinet-level council of advisers to the President on science and technology (S&T).

2.6 Regulatory and research accreditation frameworks

All countries have an extensive network of regulatory and accreditation bodies. Some, but not all, are independent of the Government. Among the Federations in the Study, Australia and Germany differ from the other two, Canada and the USA, in having centralised accreditation arrangements.

The main role of higher education accrediting agencies is to assess the quality of academic programs and institutions rather than to directly assess the quality of research. However, many accrediting agencies do have a role in assessing institutions' research capacity and resources and ensuring that research is integrated into the institution's overall academic mission.

Table 9: Comparisons of Higher Education Accreditation Frameworks

Country	Arrangements	Role in assessing research quality
Australia	Tertiary Education Quality and Standards Agency (Australia) is a nationally focused independent organisation.	TEQSA does not directly assess the quality of research, although it does evaluate the research capacity of institutions as part of its overall assessment of institutional capacity. TEQSA's uses the ARC's ERA assessment, which evaluates research quality among universities as part of its evaluation of research capacity.
Canada	Each province and territory have its own regulatory body responsible for assessing and accrediting post-secondary institutions and programs. They include the Ontario Universities Council on Quality Assurance, the British Columbia Ministry of Advanced Education, Skills and Training, and the Quebec Ministry of Education and Higher Education, among others.	Provincial and territorial accrediting bodies are generally responsible for ensuring that institutions have the necessary resources and capacity to support high-quality research. Some of these bodies, such as the Ontario Universities Council on Quality Assurance, may also assess research quality of individual programs as part of their accreditation process.
Germany	The Accreditation Council (Akkreditierungsrat) is a nationally focused independent organisation.	Research quality is not a focus of the Council.
Israel	Council for Higher Education (CHE).	CHE is responsible for ensuring that higher education institutions have the resources and capacity to conduct high-quality research.
Korea	Korean Council for University Education (KCUE).	The Council is responsible for ensuring that universities have the necessary resources and capacity to conduct high-quality research.
UK	Quality Assurance Agency for Higher Education (QAA). Office for Students for postgraduate students.	Research quality is assessed through the Research Excellence Framework (REF), which is a separate process.
USA	Regional and national accrediting bodies recognised by the US Department of Education. They include the Higher Learning Commission (HLC), the Middle States Commission on Higher Education (MSCHE), the Western Association of Schools and Colleges (WASC),	Some accrediting bodies may require institutions to have a strong research program as part of their overall academic mission. Reliance may be placed on national ranking systems that consider research quality.

Source: Internet searches.

2.7 University rankings

Australia has the highest percentage of globally ranked universities in the world[19]. There is a well-known "magic formula" that goes along the following lines:

[19] This Section draws on an op-ed in *Peals and Irritations*, published 22 March 2021 "Why do Australian universities have an obsession with rankings?"

> Revenues from international education contribute to building scale in research through income to recruit eminent staff to undertake high-quality research and purchase necessary buildings and facilities to deliver additional research outcomes, which will lift status in global rankings, attract more international students, and so on.

Of course, research-intensive universities seek high rankings for strategic objectives concerning visibility and recognition to drive international research and industry investment and collaborations.

For most universities, however, the point of rankings is to drive international student recruitment to generate revenue streams that underwrite domestic employee benefits for teaching and research, investment in property, plant and equipment, and purchase of financial assets.

Australia has the highest proportion of Times Higher Education (THE) ranked universities in the world. Table 10 shows that 84% of Australian universities are ranked, compared to 78% in the UK, 13% in Germany, 4% in the US, and 3% in China.

Table 10: THE Global rankings for Australian universities in comparison to other countries

	Australia	UK	US	Canada	Germany	Japan	China	Sth Korea	France
THE Ranking									
No in top 10	*–*	*2*	*8*	*–*	*–*	*–*	*–*	*–*	*–*
No 11-100	*6*	*9*	*29*	*5*	*7*	*2*	*6*	*2*	*3*
No 101-250	*11*	*23*	*35*	*5*	*17*	*1*	*1*	*5*	*3*
No 251-500	11	26	49	8	15	7	15	3	10
No 501+	9	41	63	12	7	106	69	27	24
Number ranked	**37**	**101**	**184**	**30**	**48**	**116**	**91**	**34**	**41**
No. of universities	44	130	4,298	103	380	795	2,688	203	n/a
Percent ranked	**84%**	**78%**	**4%**	**29%**	**13%**	**15%**	**3%**	**17%**	
Per cent in top 10	0%	2%	4%	0%	0%	0	0%	0%	0%
Per cent 11-100	16%	9%	16%	17%	15%	2%	7%	6%	7%
Per cent 101-250	30%	23%	19%	17%	35%	1%	1%	15%	7%
Per cent 251-500	30%	26%	27%	27%	31%	6%	16%	9%	24%
Per cent 501+	24%	41%	34%	40%	15%	91%	76%	79%	59%

Source: Calculated from THE data. The six Australian universities in the top 100 are Melbourne, ANU, Sydney, Queensland, Monash, and UNSW. The top 500 includes all the Go8, IRU, and ATN universities plus Wollongong, Macquarie, Swinburne, Tasmania, and Charles Sturt.

Australia has 17 universities within the 1-250 band, compared to 35 for the UK, 72 in the US, 24 in Germany, 10 in Canada, seven in China, seven in South Korea, six in France and three in Japan. There are no Australian universities in the top 10; they all come from the US and the UK.

There are many ranking systems, with some placing more emphasis on a particular metric than others. However, the results in terms of placement in a particular ranking range do not differ markedly.

Six of the top ten ranked universities are known specifically for their capability in engineering and technology—MIT, California institute of Technology, University of Oxford, University of Cambridge, Stanford University and Harvard University. However, within the top 100, five Australian universities are known for their excellence in engineering and technology[20]—

- Melbourne: aerospace engineering, biomedical engineering, computer science, electrical engineering, mechanical engineering.
- UNSW: electrical engineering, telecommunications, computer science, materials engineering, and civil engineering.
- ANU: computer science, artificial intelligence, quantum physics, renewable energy, and materials science.
- Monash: mechanical engineering, chemical engineering, biomedical engineering, and computer science.

[20] Response to ChatGPT query of 17May 2023: “Which of the top 100 Australian ranked universities are known for their capabilities in engineering and technology?”

- Sydney: aerospace engineering, robotics, civil engineering, electrical engineering, and computer science.

Under the THE ranking system, teaching, citations, and research metrics each contribute 30 per cent to the total ranking score, industry income contributes 2.5%, and international outlook contributes 7.5% (international students, 2.5%, proportion of international staff, 2.5%, and international collaboration, 2.5%).

There are some downside implications of a fixation on rankings:

- Australia has the sixth-highest average of FTE staff in the 37 top-ranking universities in each country listed in Table 10 (after the US, Canada, Germany, China, and France).
- Six Australian universities have FTEs over 40,000, compared to none in the UK, nine in the US, four in Canada, five in Germany, eight in China, 11 in France and none in Japan and South Korea. However, overseas comparisons suggest that smaller universities can deliver high rankings through better research and teaching metrics.
- Australia has 36 universities where the student to staff ratio exceeds 20:1, compared to none in the UK, one in the US, 33 in Germany, 17 in Canada, none in China, six in South Korea, and eight in France. It is hardly surprising, therefore, that Australia ranks lowest in the teaching metric by some considerable margin.
- Australia's high place in THE global university rankings is essentially driven by the citation metric, offsetting low scores in the teaching and research metrics. Because of Australia's very high international student intake, it also scores well in international outlook metric. In other words, many Australian universities are chasing rankings through citations rather than research or teaching.

Table 11 reports on the 37 Australian ranked universities' performance metrics with a score over 70 compared to the top 37 ranked universities in other countries. A score of above 70 is considered an acceptable benchmark for the purpose of this exercise.

Table 11: THE scores above 70 in universities ranked 37 and above in selected countries (numbers of universities)

Metric	Australia	UK	US	Canada	Germany	Japan	China	South Korea	France
Teaching (30%)	–	6	17	1	–	2	2	1	1
Citations (30%)	27	36	36	13	24	4	10	3	7
Research (30%)	1	7	24	3	2	2	2	1	5
International outlook (7.5%)	35	37	12	17	4	–	–	–	9
Industry income (knowledge transfer) 2.5%	3	3	–	7	2	15	6	24	13

Source: Calculated from THE data.

Table 11 indicates:

- No Australian or German universities have a score over 70 in the teaching metric.
- 27 Australian universities score above 70 on the citations metric. Only the UK and the US have more universities than Australia with a score above 70.
- Australia has only one university scoring above 70 in the research metric, compared to seven in the UK and 24 in the US.
- Australia and the UK do well on international outlook, principally due to the proportion of overseas students in each country.
- Australian universities do not generally perform well in the industry income metric.

In multiple ways, and compared to other countries, the boom in international education and the obsession with rankings has had a distorting effect on the Australian higher education system.

Rankings systems contain a heavy bias towards high citation rates, a good international outlook due to high numbers of international students but can hide relatively high student to staff ratios, and poor teaching and research scores.

It has been argued that most Australian universities should forget rankings and chasing citations and allocate more time and effort to teaching and high-quality research for application and practice that will inform teaching and engagement missions. A focus on rankings and recruiting international students distorts these priorities.

2.8 Institutional diversity in higher education

The number and characteristics of higher education institutions varies across the countries covered in the Study. A comparison of university capability is provided in Table 12.

Table 12: Comparisons of higher education capability

Country	Attributes	Number in the THE top 100
Australia	170 higher education providers in four categories. Australian University University College Institute of Higher Education Overseas University There are: 43 universities (40 Australian universities, two international universities, and one private specialty university) 127 Non-University Higher Education Providers (NUHEPs)	7
Canada	223 public and private universities, and 213 public colleges and institutes. 96 public universities.	4
Germany	456 universities, including 112 general universities (including 20 technology universities), 236 universities of applied sciences, and 108 colleges. Many technology universities use the name “'technical university” and work in close cooperation with industry.	9
Israel	Ten universities and 53 colleges.	0
Korea	190 universities, 134 junior colleges, 45 graduate schools.	3
UK	164 universities and higher education institutions.	10
USA	The Carnegie classification lists 3,939 higher education institutions. They include: 279 Doctoral high or very high research activity universities 189 Doctoral/ professional universities 667 Master’s Colleges and Universities The 146 Carnegie-classified very high research activity doctoral universities perform about three-quarters of total academic research and development (R&D).	34

Source: Various web-based documents.

Several counties have universities that are heavily oriented to engineering and technology.

- Germany has 20 technology universities out of a total of 112 general universities.
- In Korea, KAIST was established by the Korean government in 1971 as the nation's first public, research-oriented science and engineering institution.
- In many countries, particularly the US, the terms “Institute of Technology” and University are used interchangeably.
- In many countries, colleges (TAFE-type institutions) are identified as an important, strong component of the higher education system.
- It is significant in Australia that the NSW Government is developing the model of “Institutes of Applied Technology.” TAFE facilities and resources are widely used by businesses for testing, validation, and scale-up (research experimental development).

In the US, there is renewed interest in liberal arts colleges as employers look for graduates who possess not only specialised skills and knowledge but also broader intellectual and critical thinking abilities emphasised in a liberal arts education. In a rapidly changing job market, employers value employees who are adaptable, creative, and able to think critically and communicate effectively. They require a skills mix.

There is also growing recognition of the importance of interdisciplinary and cross-disciplinary learning, which is a focus of a liberal arts education. Moreover, some students and families are looking for an alternative to the large, research-focused universities that dominate higher education in the US.

Observation

2. *Based on international comparisons, it cannot be said that Australia has too many universities. In fact, there is an argument for more technology-focused universities or for some, including NUHEPs, to become more technology-focused and research-focused. There is also a convincing argument for TAFEs to extend their strong engagement with industry into more applied research. There is also an argument for more diversity in the system, with smaller universities increasing their focus on the liberal arts.*

2.9 Internationalisation

Internationalisation is a dimension of most research systems covered in the Study. It is particularly strong in Germany and other EU countries. Germany has recently published a policy paper, Internationalisation of Education, Science and Research: Strategy of the Federal Government. The first Key Point in the Strategy is reproduced in Table 13.

Table 13: Germany's Education, Science and Research Strategy.

Germany's education, science and innovation system must be organised to operate internationally if it is to persist in the face of global coopetition while living up to its responsibility to help solve the global challenges. The Federal Government is creating the right conditions for his through its Internationalisation Strategy. Against a background of increasing digitalisation, growing complexity, and the need for sustainability. We must update our methods of international collaboration. Accordingly, the Federal Government is assuming responsibility for the safeguarding of quality of life, health, and prosperity in the age of globalisation, and is drawing upon the potential of international cooperation in education, science, and research to do so. The guiding principle of this strategy is "International cooperation: networked and innovative". Education, Science and Research Strategy, page 4.

Australia has commenced engagement with the EU. Internationalisation is an essential component of Free Trade Agreements.

Internationalisation is also facilitated with "soft power" diplomacy and is where the Australian Centre for International Agricultural Research (ACIAR) makes an important contribution in the Asia-Pacific region[21].

[21] See Robyn Mudie, "Soft Power Diplomacy", Crawford Fund, June 2022.

3 Role of Stakeholders

All countries have an extensive inventory of stakeholder representation and advocacy in their higher education research systems. This creates a challenge for policy makers as they work through the tasks of policy development, implementation, and review.

It is also the case, however, that implementation is often contracted to representative organisations—but this can create challenges delivery responsibility sits alongside public advocacy.

3.1 Higher education representatives and advocacy organisations

Each country has formal and informal university and non-university groupings that represent and advocate for the interests of their members. These interests include research policies and funding, which are important elements of research systems.

Table 18 indicates the scope and scale of these organisations. No attempt has been made to assess their comparative impact on the direction of their respective research systems, but it is likely to be consequential.

Table 14: Higher Education Representative and Advocacy Organisations

Country	University Providers	Non-University Providers
Australia	Universities Australia, The Group of Eight Universities, the Australian Technology Network, Innovative Research Universities, Regional Universities Network; The Association of Australian Medical Research Institutes (AAMRI).	TAFE Directors Australia (TDA), Council of Private Higher Education (COPHE), Independent Tertiary Education Council Australia (ITECA).
Canada	U15 Group of Canadian Research Universities; Association of Universities and Colleges of Canada.	Association of Canadian Community Colleges (ACCC), Private Career Colleges Association (PCCA).
Germany	TU9: a group of nine technical universities, with a focus on science, engineering, and technology, German U15: a group of 15 leading research-intensive universities; The German Rectors' Conference (HRK), The UAS7[22] universities strategic alliance.	German Association of Private Universities and Colleges (VPH).
Israel	Ivy League of Israel: Comprises of Israel's four leading universities; The Association of University Heads (VERA), SKY universities, comprises Israel's four leading universities.	Association of Private Academic Institutions in Israel (APAII).
Korea	The Korean Council for University Education (KCUE) is an organisation that represents universities in South Korea.	Korea Association of Non-Profit Private Education (KANPE). Korea Association of Independent Colleges and Universities (KAICU).
UK	Universities UK (UUK); the Russell Group: 24 leading research-intensive universities; 1994 Group: a group of smaller research-intensive universities; University Alliance: a group of technical and professional universities; MillionPlus: a group of modern universities, with a focus on widening participation and access to higher education; the Association of Medical Research Charities (AMRC).	Association of Colleges (AoC), Independent Higher Education (IHE).
USA	Ivy League—eight private universities in the northeast; Public Ivy—public universities in the US with Ivy League-level	American Association of Community Colleges (AACC), National

[22] "Universities of Applied Sciences (UAS) were established in the early 1970s to help German industries maintain their international competitiveness. With their new approach they put higher education on a solid academic footing based on practice-oriented education and -increasingly- applied research.
"Universities of applied sciences differ from other universities by preparing students through application-oriented and interdisciplinary instruction. Although research is becoming increasingly important to UAS, teaching and practical experiences in non-academic settings are very important parts of the education. Their objective is to enable graduates to apply systematic theoretical and rigorously methods-based knowledge to resolve practical problems flexibly. This enables UAS graduates to integrate quickly into the business environment after graduation and thus provides them with a strong competitive edge for their future careers".

Country	University Providers	Non-University Providers
	academics and research; the Association of American Universities (AAU)—65 leading research-intensive universities; Historically Black Colleges and Universities (HBCUs)—colleges and universities founded with the goal of serving the African American community; The Association of American Medical Colleges (AAMC); The Association of Public and Land-grant Universities (APLU)—represents 246 public research universities as well as a number of state university systems.	Association of Independent Colleges and Universities (NAICU), Career Education Colleges and Universities (CECU).

3.2 The learned academies

The role of Learned Academies in research investment is often unrecognised, but it is very significant in some countries, particularly Germany.

The Union of German Academies, which reports a project budget of €73m and 128 projects, the Council of Canadian Academies, the US National Academies, and the American Council of Learned Societies (ACLS).

ACLS has a $US180 million endowment and a more than $US30 million annual operating budget, which it uses "to support scholarship in the humanities and social sciences and to advocate for the centrality of the humanities in the modern world."

The role of the Academies in Australia is significant but often goes unrecognised. There is perhaps an issue with "receptor arrangements" regarding how their research projects and outcomes feed into the research policy infrastructure.

Brief profiles of their role in each country follow.

Table 15: Roles of Learned Academies in Research Delivery

Country	Capability
Australia	The *Australian Council of the Learned Academies* (five members) is a forum where "Academies and our Associate Members come together to contribute expert advice to inform national policy". The ACOLA work on *Securing Australia's Future* provided important insights into Australia's science and technology future.
Canada	The *Council of Canadian Academies* has a mission to "evaluate the best available evidence on particularly complex issues where the science may be challenging to understand, contradictory, or difficult to assemble". The Council convenes many the best experts in their respective fields to "lend their knowledge, leadership, and time to serve as members of our Board of Directors and Scientific Advisory Committee". The founding members of the Council are Royal Society of Canada (established in 1882), The Canadian Academy of Engineering (1987) and the Canadian Academy of Health Sciences (2004).
Germany	The Union of German Academies – the umbrella organisation of the eight academies, many of which have long histories and a well-established place in the research system[23]. The Academies' Program is currently the largest long term research program in Germany for foundational research in the humanities and social sciences. Total funding of €72.9m, encompassing 128 projects with 188 research units (as of 2022).
Korea	The *Korean Federation of Science and Technology Societies* (KOFST), established in 1973, works with the Korean government to promote scientific and technological advancement in Korea and to foster collaboration between Korean scholars and their international counterparts.

[23] Berlin-Brandenburg Academy of Sciences and Humanities (established 1700), Göttingen Academy of Sciences and Humanities (1751), Bavarian Academy of Sciences and Humanities (1759), Saxon Academy of Sciences and Humanities in Leipzig (1846), Heidelberg Academy of Sciences and Humanities (1909), Academy of Sciences and Literature, Mainz (1949), North Rhine-Westphalian Academy of Sciences, Humanities, and the Arts (1970), Academy of Sciences and Humanities in Hamburg (2004).

Country	Capability
UK	There are 162 organisations that identify as learned societies. The most prominent are The *Royal Society of London*, established in 1660, which has active research programs, *The British Academy*, which publishes research and provides advice on policy, and *The Royal Society of Edinburgh*.
USA	The *National Academies* of science, engineering and medicine provide "independent, objective advice to inform policy with evidence, spark progress and innovation, and confront challenging issues for the benefit of society" and "marshal knowledge and expertise across disciplines to study complex and sometimes contentious issues, reach consensus based on the evidence, and identify the best path forward". There are 79 members of the *American Council of Learned Societies* (established 1919), which has a mission to "support the creation and circulation of knowledge that advances understanding of humanity and human endeavours in the past, present, and future, with a view towards improving human experience". ACLS uses its $180 million endowment and more than $30 million annual operating budget "to support scholarship in the humanities and social sciences and to advocate for the centrality of the humanities in the modern world".

The academies may sometimes confront a "receptor" problem for their work in terms of how it is taken up in research policy development and review processes.

Observation

3. **The role of the Learned Academies in guiding research investment is often unrecognised. In other countries, particularly Germany, Korea, the UK and the USA, roles are very significant in terms of advice and research investments. Drawing on that experience, the knowledge, expertise, and capabilities embedded in the Australian Learned Academies must be effectively accessed and applied in the National Research System.**

3.3 Professional associations and societies

Professional associations and institutes representing members in their professional roles have also increased their advocacy and "government relations" activities. They include engineers, architects, designers, accountants, lawyers, medical practitioners, and other professional groups.

These bodies often engage professional lobbyists to represent their points of view.

3.4 Organisations that promote university-industry collaboration

Several formal organisations have been established to promote university research collaboration.

3.4.1 UK National Centre for Universities and Business (NCUB)

NCUB is a UK-based organisation that promotes collaboration and partnership between universities and businesses. It was established in 2013 as a merger between the Council for Industry and Higher Education (CIHE) and the National HE STEM Program.

- The NCUB promotes innovation, economic growth, and social progress by fostering collaboration between universities and businesses. It provides a platform for universities and businesses to engage in dialogue, share expertise, and develop partnerships that can develop new technologies, products, and services.

- The NCUB works with universities and businesses across the UK to develop initiatives and programs that promote collaboration and partnership. It researches the impact of collaboration between universities and businesses and provides guidance and resources to support effective collaboration.

Some of the initiatives and programs that the NCUB has developed include:

- The Talent 2030 Campaign: A campaign that encourages more young people, particularly girls, to pursue careers in science, technology, engineering, and mathematics (STEM). The campaign is a collaboration between the NCUB and several businesses and universities.
- The University-Industry Collaboration Toolkit: This toolkit provides guidance and resources to support effective collaboration between universities and businesses. It covers topics such as identifying partnership opportunities, managing partnerships, and measuring the impact of collaboration.
- The Student Innovation Awards: An annual competition that recognises and rewards innovative projects students develop in collaboration with businesses. The competition is open to students from universities across the UK.

3.4.2 The Business+Higher Education Roundtable (BHER), Canada

BHER is a non-profit organisation that promotes collaboration between businesses and post-secondary education institutions in Canada.

BHER aims to develop innovative solutions to workforce development challenges and to help businesses and post-secondary institutions collaborate to create opportunities for students and graduates.

3.4.3 The Israel Industry Academic R&D Collaboration Authority (IIA)

IIA is a government agency that promotes collaboration between industry and academia in Israel. The IIA provides funding and support for research and development projects that involve industry and academic partners and aims to promote innovation and economic growth in Israel.

3.4.4 The Korea Industrial Technology Association (KOITA)

An organisation that promotes collaboration between businesses and universities in Korea. KOITA provides access to research and development resources and supports businesses in developing partnerships with universities and research institutions.

3.4.5 The Knowledge Transfer Network (KTN), UK

An organisation that promotes collaboration between businesses, universities, and research organisations in the UK. KTN provides access to funding, expertise, and resources to support collaborative research and development projects and aims to help businesses and universities work together to develop new technologies and solutions.

3.4.6 Business-Higher Education RoundTable (BHERT), Australia

BHERT was set up in 1993 to promote collaboration and partnership between businesses and higher education institutions in Australia. It does not appear to be operative—its website, http://www.bhert.com/, has been hacked.

In Australia, peak industry associations, particularly the Business Council of Australia play an important role in promoting business-higher education collaboration.

Observation

4. **In all the countries covered in the Study, business-higher education collaboration organisations, such as the UK National Centre for Universities and Business (NCUB) and the Canada Business+Higher Education Roundtable (BHER), play an important role in promoting collaboration and partnership between universities and businesses. They provide a platform for dialogue, share expertise, and develop partnerships that can lead to the development of new technologies, products, and services. In Australia, key stakeholders may consider measures to strengthen the Australian Business-Higher Education Round Table using overseas practice as a guide.**

3.5 Research brokers

All countries in the Study have developed arrangements for knowledge brokerage, knowledge networks, and knowledge mobilisation. However, there is little consistency in approach, and only a few countries have embarked on centrally coordinated initiatives. Fewer have developed arrangements for research brokerage.

Knowledge brokerage refers to facilitating the exchange and transfer of knowledge and information between different individuals, organisations, or sectors. Depending on the context and objectives, it can take various forms. For example, it can involve connecting researchers and practitioners, linking different research disciplines or sectors, or mediating between experts and policymakers.

Knowledge brokers typically facilitate dialogue and collaboration, promote knowledge sharing, and create platforms for knowledge exchange and mobilisation. Increasingly, digital platforms are being developed for these purposes.

Knowledge exchange networks are sponsored and maintained across various institutional arrangements. These include:

- Networks formed through the initiative of researchers in universities and publicly funded research organisations
- Networks supported by industry and professional associations
- Networks supported by government programs and initiatives
- Collaborative business and enterprise networks involving participation from industry, research organisations and business associations
- Networks formed as an outcome of government enterprise development programs

Knowledge mobilisation aims to enhance the impact and relevance of research by making it accessible and usable by various stakeholders, including policymakers, practitioners, organisations, and communities. It goes beyond traditional modes of dissemination, such as academic publications, to engage with and involve end users throughout the research process.

The role of knowledge brokers, innovation intermediaries, and technology transfer offices in connecting research with innovation is addressed in Section 10.

The role of a *research broker* differs from that of a knowledge broker or innovation intermediary who is concerned with knowledge transfer for application and commercialisation (addressed in Section 6). A research broker is focused on *creating knowledge* by connecting researchers rather than translating or transferring it. It involves looking for and capturing potential knowledge spillovers in the research system to encourage breakthrough research.

Research brokerage tends to rely on existing professional and personal networks, which can be closed and limiting and might miss critical potential interactions—particularly outside a research discipline. Without new interactions and connections, research is likely to become routine and "research as usual".

Internationally, the peak bodies of the learned academies, professional institutes, and associations have important roles as research brokers and are well-resourced to carry out this role (see Section 3.2, page 26, above). In Australia, those roles are not as well developed. However, as member-led organisations, they tend to have a national rather than international focus and are organised around research disciplines rather than commitments to cross-disciplinary research and knowledge creation.

Observation

5. **Although most countries in the Study have strong commitments to knowledge transfer translation, there appears to be a limited commitment to research brokerage—creating knowledge by connecting researchers rather than translating or transferring it. It involves looking for and capturing potential knowledge spillovers in the research system to encourage breakthrough research. While peak bodies of the Learned Academies have important brokerage roles, particularly in Canada, Germany, the UK and the USA, the reach in Australia may be more constrained. Australia may benefit if more attention is paid to fostering research broker capability within the Learned Academies and professional institutes to further research collaboration in Australia and internationally.**

3.6 Research intermediary organisations

Most research intermediary organisations are researcher-oriented rather than institution-oriented, although personal connections may become reflected in institutional collaborations. Some intermediary initiatives are outlined below.

Alexander von Humboldt Foundation

The Alexander von Humboldt Foundation is an intermediary organisation for German foreign cultural and education policy. It aims to promote international cultural dialogue and academic exchange.

The Humboldt Foundation offers flexible sponsorship programs. Its research fellowships and awards enable outstanding scientists and scholars from abroad to complete long term research stays in Germany.

There are no quotas for specific countries or subjects; only personal academic achievement counts. The Foundation also maintains close links with its alumni, the Humboldtians, after their stay in Germany. It offers numerous alumni support programs for that purpose.

The budget of the Alexander von Humboldt Foundation amounted to roughly €143m in 2019. The Foundation receives approximately 96% of its funding from federal sources. The following ministries contribute to its budget:

- Federal Ministry of Education and Research (BMBF)
- Federal Foreign Office (AA)
- Federal Ministry for Economic Cooperation and Development (BMZ)
- Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU)

DAAD: The German Academic Exchange Service (DAAD)

DAAD is a similar organisation to the Alexander von Humboldt Foundation. It provides funding and support for international students, scholars, and researchers to study and conduct research in Germany.

Marie Skłodowska-Curie Actions

The Marie Skłodowska-Curie Actions is a program funded by the European Union that provides grants and fellowships for researchers to study and work in Europe.

Japan Society for the Promotion of Science

The Japan Society for the Promotion of Science (JSPS) is a non-profit organisation that provides funding for research and facilitates international scientific exchange between Japan and other countries.

Fulbright Program

The Fulbright Program is an international educational exchange program funded by the US government. It offers grants to students, scholars, teachers, and professionals from around the world to study, teach, or conduct research in the United States.

The Australia New Zealand Association for the Advancement of Science (ANZAAS)

ANZAAS was a scientific society founded in 1888 to promote science and technology in Australia and New Zealand. The society organised annual conferences and published a scientific journal, ANZAAS Transactions.

In the mid-20th century, ANZAAS became an important institution for the scientific community in Australia and New Zealand, playing a key role in promoting scientific research and education in the region. However, in the late 20th century, ANZAAS faced financial difficulties and declining membership, and it eventually ceased operations in the 1990s.

Its functions have been taken up by scientific societies and organisations in Australia and New Zealand that continue to promote scientific research and education in the region, including the Australian Academy of Science, the Royal Society of New Zealand, and the New Zealand Association of Scientists.

Researchers who are not connected with these societies or not aware of processes may be disadvantaged.

Recommendation

6. **Countries covered in the Study have developed strong capabilities in research intermediation to promote international cultural dialogue and academic exchange. These include the German Alexander von Humboldt Foundation (funding of €143m in 2019), Academic Exchange Service (DAAD), the EU Marie Skłodowska-Curie Actions Program, and the US Fulbright Program. Drawing on these experiences, the Department of Education may consider extending its programs to build international researcher connections and networks at all stages of their careers.**

4 Significant Funding Programs

This Section provides information about major funding programs in the research systems of the countries covered by the study.

4.1 Government direct investment

An indicative listing of the major Government research programs in each country is provided in Table 16 on page 33 below. For comparison, amounts are reported in $US. Some observations on the programs include—

- The significance of tax credit/concession programs in Australia and Canada.
- The amounts allocated to the Canada Research Councils and the UK Research Councils are significantly larger than those to Australia's ARC ($US741m).
- The size and scope of the German research investment programs.
- The allocations to US NSF programs will increase as the amounts provided under *the Chips and Science Act* flow to annual appropriations.
- The German government made a very large investment in "Coordinates" programs, including Collaborative Research Centres.
- The Korean government made very large engineering and technology investments.

Table 16: Major research funding programs ($US, estimated)

Australia	Canada	Germany	Israel	Korea	UK	USA
Programs and activities identified in the SRI budget tables valued at over $100m (2022-23 budget): R&D Tax Incentives – $US2.4 billion Research Training Program $US736m CSIRO $US670m Research Support Program $US643m NHMRC $US607m ARC $US600m MRFF $US434m DST Group $US320m ARENA $US211m NCRIS $US193m ANSTO $US179m Antarctic Division $US150m National Institutes - ANU $US146m CRC Program $US135m Defence Innovation Hub $US82m GRDC $US71m ACIAR $US69m	Programs and resourcing include: Canada Tax Credit $US2.7 billion Tri-agencies Canada Natural Sciences and Engineering Research Council $US816m Canadian Institutes of Health Research $US977m Social Sciences and Humanities Research Council of Canada $US389m Canada First Research Excellence Fund, administered by the tri-agencies—$US148m annually since 2015. Canadian Nuclear Laboratories $US370m Canadian Space Agency $US296m Canada Research Chairs Program $US265m Foundation for Innovation $US222m Mitacs $US196m Genome Canada $US111m Canada Excellence Research Chairs Program $US37m	DFG Projects and Programmes $US10.6 billion— Individual Grants $US3,706m Coordinates programs $US4,590m— *Collaborative Research Centres $US2,490m* Priority Program $US534m Research Units $US534m Research Training Groups $US683m Research Centres $US81m Excellence initiatives $US1,509m Infrastructure funding $US630m BMBF (Ministry of Education and Research) 2023 budget of $US23.6 billion includes: $USS8.9 billion for Institutional research funding (a cut) Strategy for the Future of Research and Innovation to be funded. Support from the EU Sovereign Tech Fund	Israel Science Foundation $US150m US-Israel Binational Science Foundation $US120m Israel Innovation Authority $US400m Israel Cancer Research Fund $US100m Ministry of Science and Technology $US80m Chief Scientist's Office $US50m Israel Academy of Sciences and Humanities $US20m Israel-US Binational Agricultural Research and Development Fund $US20m	Advanced Institute of Science and Technology $US800m Electronics and Telecommunications Research Institute $US500m Institute of Science and Technology $US450m Aerospace Research Institute $US300m Institute of Energy Research $US200m Institute of Industrial Technology $US200m Institute of Construction Technology $US160m Research Institute of Chemical Technology $US150m Institute of Machinery and Materials $US170m Institute of Geoscience and Mineral Resources $US120 million Institute of Nuclear Safety $US110 million Research Institute of Standards and Science $US100m Brain Research Institute $100m	UK Research Partnership Investment Fund (UKRPIF) $US1.1 billion (2018-21) National Institute for Health $US1.3 billion Medical Research Council $US1.1 billion Engineering and Physical Sciences Research Council $US1.1 billion Science and Technology Facilities Council $US910 million Cancer Research UK $US805 million Biotechnology and Biological Sciences Research Council $US670 million Natural Environment Research Council $535 million Economic and Social Research Council US$255 million. Francis Crick Institute $US200 million Rosalind Franklin Institute $US134 million The European Molecular Biology Lab $US120 million	From the latest NSF Budget Request Advanced Manufacturing $US453.86m Advanced Wireless $US179.17m Artificial Intelligence $US796.48m Biotechnology $US470.05m Microelectronics and Semiconductors $US209.68m Quantum Information Science (QIS) $US332.67m Clean Energy Technology (CET) $550.51m US Global Change Research Program (USGCRP) $US1,047.06m Major Facilities operations and maintenance (O&M) $US1,069.80m The Major Research Instrumentation (MRI) $US92.75m

					The Alan Turing Institute $US134 million	

4.2 Philanthropy

Philanthropy is a significant source of income for several universities and not-for-profit providers. Philanthropy generally covers gifts, donations, and bequests. Many universities have active advancement strategies designed to elicit gifts from alumni and businesses associated with the institution. US universities are the most sophisticated in this activity.

Donations from charitable foundations are also a significant form of research income and have become an important feature of the research investment framework.

- In Australia and the UK, charities and charitable foundations are heavily oriented to medical research.
- The Paul Ramsay Foundation, one of Australia's largest philanthropic foundations, has invested over $600 million in medical, mental health, and Indigenous health research. The Ian Potter Foundation has invested over $300 million in research and innovation. The Lowy Foundation supports international relations, public policy, and national security research.
- In the UK, the Leverhulme Trust, the Nuffield Foundation, and the Royal Society support mathematics, engineering, and physics research.
- In Germany, the Foundations take a broader remit, such as the Volkswagen Foundation (natural sciences, social sciences, and humanities), the Robert Bosch Foundation (scientific research, social innovation, and cross-sectoral projects, and The Klaus Tschira Foundation (science education, scientific research, and science communication).
- The US has some very large Foundations. The Bill and Melinda Gates Foundation, one of the largest philanthropic organisations in the world, has invested over $54 billion in various programs, including research and development related to global health and education.
- The Ford Foundation has invested over $17 billion in research and advocacy related to social justice and human rights, and the Rockefeller Foundation has invested over $2 billion in various programs, including research and innovation related to public health, agriculture, and urbanisation.

4.3 Borrowing

R&D is an investment, and organisations may choose to borrow to finance investment projects because there will be a stream of returns in future years. Publicly listed companies may finance a major capital investment by raising or issuing shares.

Universities increasingly issue financial instruments to finance capital expenditures, particularly large scale infrastructure projects such as research facilities or laboratories.

- They issue bonds or other debt securities to finance capital expenditures, including research-related investments.
- Universities are generally advantaged in borrowing due to their very high credit ratings.
- Universities in all countries included in the Study can borrow to finance capital expenditure from banks, government agencies, and capital markets. Borrowings are generally subject to borrowing limits and regulatory requirements.
- Some universities in Australia have substantial borrowing levels used to finance capital expenditures, including research facilities, and some have none.

Consolidated information on how much individual universities borrow to finance R&D investment is not available, although the information exists in individual university financial statements.

Borrowing is easy for the larger metropolitan universities but challenging for other universities. Some countries have pooled or concessional borrowing arrangements that universities can access. Several international initiatives exist, including the California State University System's Capital Projects Funding and Fees arrangements.

Government research agencies have limited borrowing capacity, particularly if they are financed "on budget" or are limited in their capacity to retain earnings.

Observation

7. **Universities in all countries included in the Study can borrow to finance capital expenditure from banks, government agencies, and capital markets. Borrowings are generally subject to borrowing limits and regulatory requirements. Borrowing is easy for the larger metropolitan universities but is challenging for other universities. Some countries have pooled or established concessional borrowing arrangements that universities can access. There could be advantage in a review of mechanisms in Australia to more effectively pool or facilitate governance on borrowing arrangements for universities. The purpose would be to finance research facilities, particularly for smaller/regionally based universities that may not have the larger metropolitan universities' financial leverage (strong balance sheets and AA credit ratings).**

4.4 University retained earnings

Universities with strong balance sheets and cash flows can invest in research through retained earnings and cash. The extent to which higher education institutions utilise retained earnings to finance research, particularly research facilities, is not easily discernible from university financial statements. However, preliminary investigation indicates that approach is not uncommon:

- The University of Technology Sydney used retained earnings in 2015 to fund the construction of the Dr. Chau Chak Wing Building, a state-of-the-art facility for the UTS Business School.
- The University of Adelaide has used retained earnings from commercial activities to fund research infrastructure development in areas such as agriculture, health sciences, and engineering.
- The University of New South Wales has used retained earnings to fund research infrastructure projects in renewable energy, materials science, and biomedical engineering.
- The University of Melbourne has used retained earnings from the commercialisation of research to fund the construction of new research facilities, including the Melbourne Brain Centre and the Bio21 Molecular Science and Biotechnology Institute.

4.5 Public-private partnerships

A public-private partnership is a contractual arrangement between a university and a private sector entity to jointly deliver university buildings and facilities, including those for research. The public-private partnership instrument allows universities to preserve cash and relieves pressure on government budgets. Clearance from State Treasuries is generally required.

The vehicle is used extensively overseas and is becoming more common in Australia. Recent examples are shown in Table 17.

Table 17: Recent University Public Private Partnerships

University	Project
Monash University	In 2019 entered a public-private partnership with Plenary Group and CIMIC Group to develop the $1.1 billion New Student Precinct, which includes research facilities, student accommodation, and other amenities.
The University of Queensland	Partnered with Plenary Group to develop the $250 million Translational Research Institute, a research facility focused on developing new treatments and technologies for diseases such as cancer, diabetes, and infectious diseases.
University of Wollongong	The entered a public-private partnership with Plenary Group to develop the $360 million Molecular Horizons research facility, which includes state-of-the-art equipment and technology for research in areas such as drug discovery and precision medicine
Deakin University	Partnered with IFM Investors to develop the $550 million Deakin Downtown campus in Melbourne, which includes research facilities, student accommodation, and other amenities.
The University of Melbourne	Entered a public-private partnership with Lendlease to develop the $1 billion Melbourne Connect innovation precinct, which includes research facilities, commercial spaces, and accommodation for students and researchers
University of Sydney	Partnered with CPB Contractors to develop the $500 million Charles Perkins Centre, a research facility focused on addressing obesity, diabetes, and cardiovascular disease.
The University of New South Wales	Entered a public-private partnership with Plenary Group to develop the $1.2 billion Randwick Health Precinct, which includes research facilities, hospitals, and other health-related infrastructure.
Imperial College London	Developed the Imperial College Translation & Innovation Hub and the White City Campus through a public-private partnership.
The University of California, Merced	Partnered with Plenary Properties Merced to develop the $1.3 billion Merced 2020 Project, which includes a new research and academic centre, student housing, and other facilities.
The University of Saskatchewan in Canada	Entered a public-private partnership with EllisDon Infrastructure to develop the Collaborative Science Research Building, which includes state-of-the-art research facilities and collaborative spaces.
Stanford University	Partnered with the private equity firm Redwood City to develop the Stanford Research Park, a research and innovation hub.

4.6 Tax credits (R&D tax expenditures)

The most significant level of support for R&D in the countries in the Study is tax credits, or "tax expenditures", provided through the taxation system. Tax credits may support university investments.

Arrangements vary, but all allow expenses that include payments to universities under conditions like the Australian provisions –

> *activities must meet the definition of R&D, which is a systematic, investigative process involving innovation, experimentation, or analysis that aims to gain knowledge and develop new or improved products, processes, materials, devices, or services.*
>
> *The company claiming the tax offset must have control over the university's R&D activities, which means that the company must be actively involved in managing, directing, and supervising them.*

Some countries allow both companies and individuals to claim the Tax Credit.

Brief information on the designation of tax credits, maximum benefit, and cost in each of the countries in the Study is in Table 18.

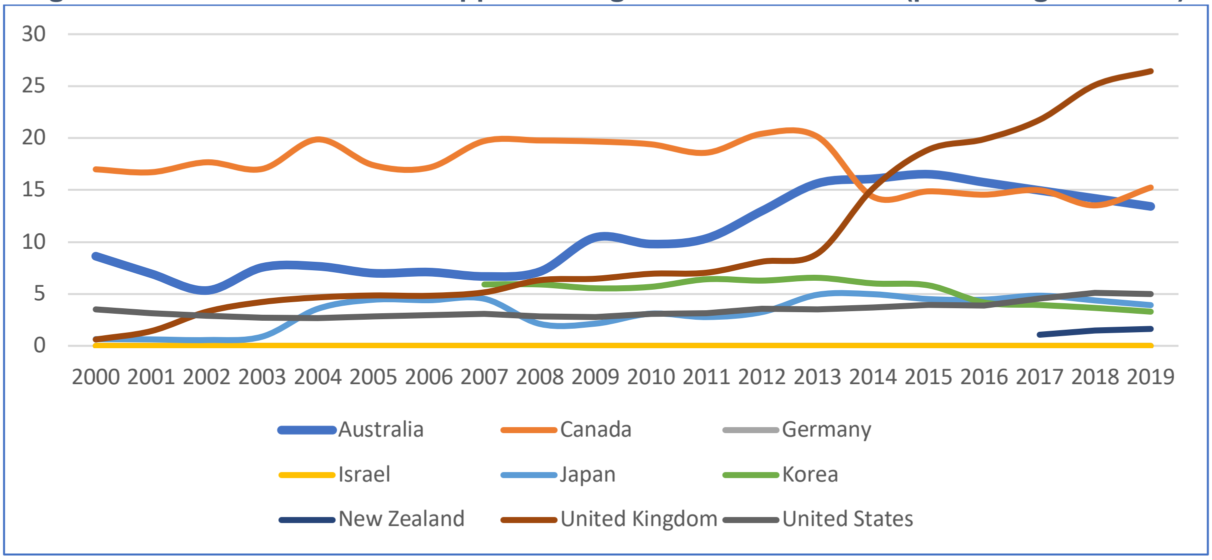
Table 18: Designation of tax credits, maximum benefit, and cost

Country	Name	Maximum benefit	Number of recipients	Cost
Australia	Research and Development Tax Incentive (RDTI)	43.5%	14,000	$A2.4 billion (2018-19)
Canada	Scientific Research and Experimental Development Tax Credit	35%	41,000	$C4.26 billion (2018)
Germany	Research Allowance Act	25%	10,000	€1.4 billion (2020)
Israel	The R&D Law	50%	12,500	$US1.9 billon (2020)
South Korea	R&D Tax Credit	40%.	28,000	$US3.7 billion (2020)
United Kingdom	R&D Tax Credit	13%	62,095	£5.3 billion (2019-20)
USA	Research and Experimentation Tax Credit	20%	20,000	$US13.1 billion (2016)

Australia’s tax credit arrangements are the most generous among the countries in the Study.

In 2019, Australian tax incentives (the RDTI) supported 13.4% of business expenditure on R&D, well below the UK (26.4%) but much more than Japan, Korea, or the US. Trends since 2000 are shown in Figure 7.

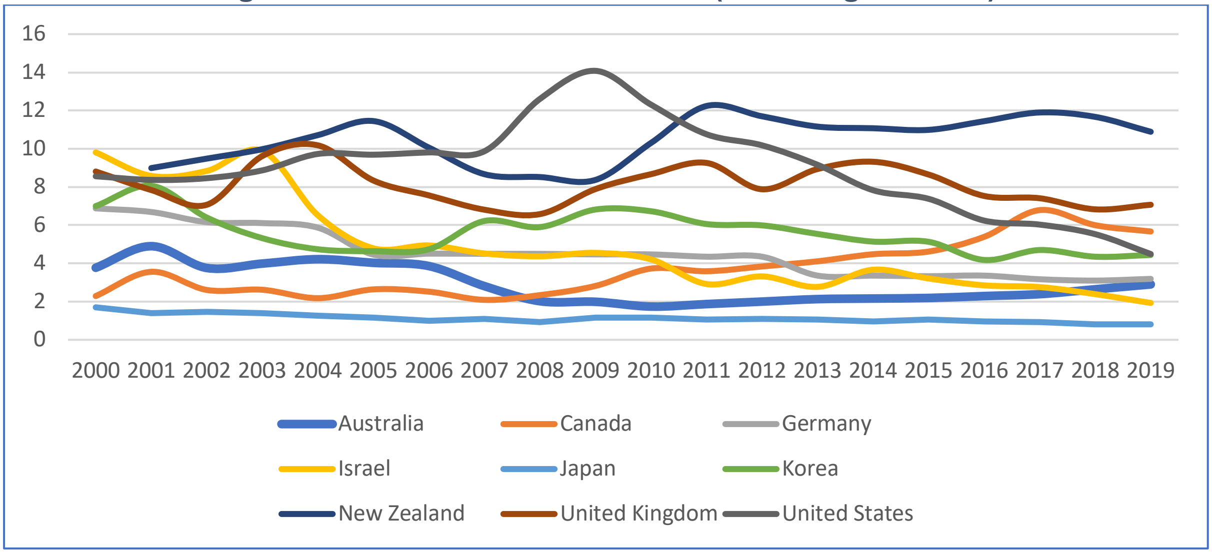
Figure 7: Indirect Government support through R&D tax incentives (percentage of BERD)



https://www.oecd.org/sti/rd-tax-incentive-indicators.htm

By contrast, direct business support for business R&D in Australia amounted to only 2.9% of total business expenditure on R&D in 2019, compared to 5.7 % in Canada, 4.4% in Korea, 7.1% in the UK and 4.5% in the USA. Trends in these proportions are shown in Figure 8, including the drop in the USA from a peak of 14.1% in 2009.

Figure 8: Government-financed BERD (Percentage of BERD)



https://www.oecd.org/sti/rd-tax-incentive-indicators.htm
See also https://stip.oecd.org/innotax/

Tax credits are intended to stimulate business investment, and the benefits can flow to universities if the claimed expenses involve expenditures on university research.

In 2020, Australia spent 0.13% of its GDP on tax relief, well below the UK (0.31%) but on par with the other countries included in the Study. Australia dropped from a lead position of 0.19% of GDP in 2012.

Observation

8. **The most significant level of support for R&D in the countries in the Study is tax credits, or "tax expenditures", provided through the taxation system. Tax credits may support university collaborative research investments under certain conditions. In 2019, Australian tax incentives (the RDTI) supported 13.4% of business expenditure on R&D, well below the UK's (26.4%). Despite the scheme being the most generous among OECD countries and costing $A2.4 billion, the OECD reports that Australian Business R&D has fallen from $US12.3 billion in 2009 to $US11.1 billion in 2019 (2015 Dollars Constant prices and public-private partnership). Consideration may be given to reviewing the effectiveness of RDTI resources to provide more specific forms of research program support that foster higher education research collaboration.**

5 Similarities and Differences in Overseas Research Funding Systems Compared to Australia

The research funding systems covered in the Study are quite different in many respects, but there are similarities. These issues are addressed below.

5.1 Scale and scope: a key differentiator

The populations of each country in the Study range from 9.4 million in Israel to 331.9 million in the US. These differences impact the scale of financial resources and human capabilities available and potentially available to commit to research and development.

GDP is measured in purchasing power parity (PPP), and based on 2015 constant prices, it ranges from $US378.5 million in Israel to $US20,529.4 million in the US. Australia's GDP under this measure is $US1,280.4m[24].

The scale and scope of R&D differ markedly. This is indicated in Table 23, which shows national expenditure on R&D in terms of constant prices and PPPs for countries frequently referenced for comparison with Australia 25. Data is presented for the latest years available on the OECD database, which are either 2019 or 2020[25].

Table 19: National expenditure on R&D 2019, 2020 (2015 $US - constant prices and PPPs)

	Business	Government	Higher Education	Not-for-Profit	Total
USA	510,409	61,315	74,381	25,859	671,964
China (PPR)	395,135	79,880	-	-	475,015
Japan	131,417	13,829	19,550	2,286	167,082
Germany	83,684	18,366	23,517	-	125,567
Korea	81,356	10,399	9,234	1,891	102,880
UK	55,662	3,896	17,547	1,048	78,153
France	42,139	7,880	12,852	1,052	63,923
Taiwan	38,170	4,419	3,591	59	46,239
Canada	16,821	2,336	11,804	124	31,085
Australia	**11,095**	**2,149**	**7,524**	**831**	**21,599**
Netherlands	13,893	1,171	5,801	-	20,865
Israel	17,972	240	1,524	146	19,882
Sweden	12,722	801	4,200	21	17,743
Singapore	7,254	1,409	2,773	-	11,436
All countries	1,428,474	209,375	198,096	33,375	1,869,320

Source: OECD. Stat, accessed 11 May 2023

Table 19 indicates the vast differences in the scale of R&D spending between countries.

- The US has a total spend of $US672 billion—a thirty-fold difference from Australia ($US22 billion). China has also been making a growing commitment to R&D, at $US475 billion.
- A second tier is Japan, Germany, and Korea each with R&D expenditures over $US100 billion. Also, as a Federation, Germany's R&D is also concentrated in four of the nine Lander (States).[26] The Lander also have parallel research systems. However, they contribute 30% of the National Science Foundation (DRG) budget.
- Canada ($US31 billion) and Australia ($US22 billion) constitute a third tier. Both are Federations, with R&D concentrated in a relatively small number of States or Provinces. Due to scale, there is little scope for parallel systems.

[24] Unless otherwise stated, all comparative data is comparative sourced from the OECD Research and Development Statistics and expressed in 2015 $US—Constant Prices and Purchasing Power Parity (PPPs).
[25] A few small countries have updated data for 2021.
[26] Bavaria, Baden-Württemberg, North Rhine-Westphalia, Lower Saxony. Berlin has a vibrant start-up ecosystem.

- A fourth tier covers Israel ($US17.1 billion)—of which 49.5% is funded from overseas.
- Third- and fourth tier systems cannot replicate the research diversity and intensity of the USA, Germany, and Korea: to attempt to do so would mean sub-scale operations and fragmentation in institutional frameworks. It follows that in third- and fourth tier countries, research investment must be targeted in areas where the country is globally recognised and reflects genuinely niche and distinctive capabilities and abilities.
- Of course, distinctive capabilities can be created through missions, policies, and strategies. These must ensure meaningful priorities, and that expensive and high-quality research infrastructure is available to meet specific needs and requirements, particularly in providing leverage for international research collaborations.

However, differences in scale and scope between research systems among different countries create a constraint on what may be adopted and applied in another nation. There are also fundamental constitutional, socio-political, and institutional differences between countries that are not easily comprehended simply by looking at financial, output and impact data. *Context is critical*.

International comparisons are essential in looking for good practice and good ideas, but they do not, in themselves, provide an easily transferable solution for addressing national research performance options and opportunities.

In Federal systems, be they governments or corporations, large scale will push towards devolution not so much to achieve economies through specialisation and division of work but to achieve *effectiveness* as different operational units can focus on their markets and operating environments. The scale of the US research system requires devolution, whereas the small-scale Australian system has a lesser imperative.

5.2 Australia and Canada

Australian and Canadian similarities in their research systems are reflected in their federal structure, with responsibilities in education and research shared between a central government and State/Provincial governments. In addition—

- Each has very low proportions of R&D in GDP—the lowest of the Study countries.
- They rely heavily on higher education to build the national research effort.
- Both countries have comparatively very low levels of business expenditure on R&D as a proportion of total R&D—at 51.4% and 53.7%, respectively, compared to an average across the countries in the Study of 73.1%.
- It is only recently that political leaders in both countries have discussed the importance of R&D to economic growth.
- The research systems are governed by a Ministry/Department rather than assigned to a separate Research Foundation, as in Germany, Korea, and the USA. The UK has devolved governance to an executive, non-departmental public body.[27]
- Both countries invest significant funds for research through Ministries/Departments. Seven can be identified for Australia and Canada. Australia has 17 Ministerial portfolios, and Canada has 20. The Federal Government of Canada does not have a Ministry of Education. (Germany has 15 Federal Ministries).
- Both countries support research through "investment funds", although Canada has more.

[27] UK Research and Innovation (UKRI) is the national funding agency that invests in science and research in the UK. In limited circumstances. The Secretary of State for Business, Energy and Industrial Strategy has the power to issue directions to UKRI in relation to its functions and funding.

- Both countries have a portfolio of national research centres and institutes and many research centres within Ministry/Departmental structures to perform mission-based research.

The research systems in each country are highly complex, with multiple organisations with varying roles and responsibilities for decision-making regarding resource allocation, research delivery, quality, and accountability. There are also complex interfaces between the science and engineering systems and the innovation systems.

Like Australia, Canada does not have a national research strategy. Strategies are embedded in individual research councils and separate ministries, such as Innovation, Science and Economic Development, and Health and other portfolios in Canada[28].

Table 20: Parallels between the Australian and Canadian Research Systems

History: Both Australia and Canada were British colonies and inherited many aspects of the British research system at the time. This includes having a focus on empirical research and a strong tradition of academic excellence. Both countries are constitutional monarchies and parliamentary democracies that adopt the Westminster system of responsible and accountable government. There are parallels in the Machinery of Government and Public Administration. **Federal structure**: Both countries are Federations with powers shared between a central government and States/Provinces. In both countries the universities are “creatures” of State/Provincial governments. In 1974 the Australian Federal Government took over full financial responsibility for funding university teaching (but not specifically research, which has been covered by the Australian Research Grants Committee). In Canada, the Provinces still maintain a major role in teaching. Canada does not have a Ministry of Education. **Lack of commitment to R&D and ambivalent political interest:** Both countries have very low proportions of R&D in GDP—the lowest of the Study countries. It is only recently that political leaders in both countries have engaged with the importance of R&D to economic growth. **Research delivery:** Both countries have many research centres within Ministry/Departmental structures to perform mission-based research. In Australia a large amount of this capability was removed because of the influence of New Public Management thinking associated with fiscal austerity. The impact of NPM in Canada was possibly not as severe as it was in Australia[29]. **Strong democratic traditions**: Both countries have strong democratic traditions, which have supported the development of research systems that are independent and free from political interference. **University structures:** Both countries have many research centres within Departmental/Ministry structures to perform mission-based research. **Language and culture**: Both Canada and Australia have English as their official language (and French in Canada), and similarities in their socio-political cultures.

5.3 Australia and Germany

Germany places relatively greater importance on Government R&D —14.4% of the total research effort.

The main similarity between the countries is the federal constitutional structure, but the German Lander take a much greater role in the research system than the Australian States/Territories.

[28] Unlike Australia, Canada does not have a separate Education Ministry.
[29] Australia adopted a quite radical version of NPM in the 1980s and 1990s, involving policies of competitive tendering, outsourcing to the private sector, and aggressive public service “downsizing”. Like Australia, Canada focused on improving efficiency and effectiveness by decentralising decision-making, increasing accountability, and introducing market-like mechanisms such as performance-based funding and user fees. The Canadian government did not adopt some of the more radical NPM measures, such as privatisation and widespread contracting out of services to the private sector.

- The German system, reflecting historical antecedents, is organised more systematically with a high degree of collaboration between the Federal Government and the States. The German socio-political culture provides strong underlying support for R&D investment.
- Like Australia, the German administrative model strongly emphasises legal-rational principles. Administrative actions are based on formal rules, procedures, and legal frameworks. Bureaucratic structures and hierarchical decision-making are prominent features.
- Unlike Australia, however, Germany emphasises professional expertise in decision-making and policy implementation. Officials are expected to possess specific knowledge and skills in their respective fields, which contributes to the perceived legitimacy and effectiveness of administrative actions.

A recent publication, *German Public Administration: Background and Key Issues*[30], points out:

> In the international community of Public Administration (PA) of scholars and practitioners, there is a growing need to acquire knowledge and information, analysis, reviews and evaluations about Germany's administrative system and its recent reforms.
>
> The German system of public administration, which is embedded in the Rechtsstaat culture and deeply rooted in the legalist tradition, is not simply regarded as a reference model for developing and transition countries. The basic features of the German administrative system have also inspired reform debates and modernisation efforts in OECD countries (Organisation for Economic Cooperation and Development).
>
> Due to its federal structure and the pronouncedly decentralised institutional setting, German public administration is regarded as a prime example of multilevel governance and strong local self-government.
>
> Against this background, it is a cause for concern and criticism that there has been no English language publication about German administrative systems on the market for about 20 years, when the German Section of the International Institute of Administrative Sciences (IIAS) published the last volume.

In these respects, Australia has much to learn from the German situation. Regrettably, however, public administration is no longer a focus of teaching and research in Australian universities; the emphasis has shifted to public policy and politics.

5.4 Australia and Israel

A combination of European, British, and American systems influences Israel's administrative model. Policy commentators have pointed to Israel as a research system model for Australia, particularly when looking at the start-up ecosystem.

There are similarities in the commitment to clinical research, but the systems are quite different overall.

- In both countries, public research funding is largely driven by the government. The Israeli government plays a significant role in supporting research and development through funding agencies like the Israel Innovation Authority (IIA), the Israel Science Foundation (ISF), and the Ministry of Science and Technology.
- While Australia's public research system focuses on a broad range of disciplines, spanning natural and social sciences, humanities, engineering, and medical research, in Israel, the system places a strong emphasis on technological innovation, particularly in areas such as high-tech industries, defence, agriculture, water technologies, and cybersecurity. These areas are now gaining greater prominence in Australia with the introduction of the National Reconstruction Fund with a focus on application of technologies (experimental development) through loans rather than grants.

[30] Kuhlmann, S., Proeller, I., Schimanke, D., Ziekow, J. (2021). *German Public Administration: Background and Key Issues*. In: Kuhlmann, S., Proeller, I., Schimanke, D., Ziekow, J. (eds) Public Administration in Germany. Governance and Public Management. Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-030-53697-8_1

- Israel's research sector is closely integrated with industry, aiming to drive economic growth, entrepreneurship, and commercialisation of research outcomes. Israel is known for its strong emphasis on applied research and the commercialisation of technological advancements.
- Although Australia has many initiatives promoting international research collaboration, such as joint research projects, student exchanges, and academic network, in Israel, international collaboration is valued particularly highly. It sets out to leverage expertise in research institutions, universities, and companies to access global markets.

The Israeli system relies on over 50% of research funding from international corporations and government agencies—making it very different from Australia.

5.5 Australia and Korea

The Korean research system has an advantage with the close involvement of its global corporations in higher education research.

Korea's post-war economic development "miracle" has been driven by major economic reforms, integration into the global economy together with a very strong US financial commitment to the Korea Advanced Institute of Science and Technology (KAIST).

About KAIST - Korea Advanced Institute of Science & Technology

Formerly known as the Korea Advanced Institute of Science and Technology, KAIST was South Korea's first research-oriented science and engineering institution when it was founded in 1971.

For such a young university, KAIST's standing is growing rapidly: it is widely acknowledged as the best university in Korea and has been named the most innovative university in the Asia-Pacific region.

One of its stand-out research projects of recent years saw researchers develop an electric transport system, where vehicles get power from cables underneath the road via non-contact magnetic charging. It's an example of how KAIST is leading the field in developing new technologies that might tackle world problems such as energy consumption and congestion in cities.

Around 10,000 full-time students attend KAIST, split between 4,000 undergraduates and 6,000 postgraduates. Science, engineering, and technology are the school's main focuses, though the university has branched out in recent years and is now internationally accredited in business education too. It has also adopted dual degree programs with leading world universities such as Carnegie Mellon in the United States and the Technical University of Berlin, and these offer its students diverse educational opportunities.

https://www.topuniversities.com/universities/kaist-korea-advanced-institute-science-technology

Similarities and differences include:

- While Australia's public research system focuses on a broad range of disciplines and research areas, in Korea, there is a very strong emphasis on strategic and applied research in areas such as information technology, electronics, energy, and materials science.
- Although both countries provide substantial government funding for research, the degree of involvement and investment differs. Through the National Research Foundation of Korea, the government plays a more direct and substantial role in research with a major commitment of financial resources, setting strategic priorities, and actively supporting research institutes and universities. Australia does not have a National Research Foundation to perform these roles.
- The Korean government has launched initiatives such as Brain Korea 21 (BK21) and World-Class University (WCU) projects to enhance research capabilities and attract talented researchers. The Australian (national) government has launched no such initiatives in

recent years. State governments launch many economic development initiatives in Australia.

- While the Australian research culture tends to emphasise academic freedom and a collaborative approach across institutions and disciplines, in Korea there is a strong focus on applied research, technology transfer, and industry collaboration.
- Korean research institutes and universities work closely with industry partners, to drive economic growth, technology commercialisation, and innovation. A close alignment of research priorities with national economic goals characterises the Korean research culture. Australian research policy struggles to connect these outcomes.

5.6 Australia and the UK

Like Australia, the UK public research system is the "product of decisions taken over many years and reflects changing, sometimes short-term, public policy priorities and initiatives, and varied approaches to public funding of research" (Sir Paul Nurse, 2023).

Similarities include:

- In the UK, Research and Innovation (UKRI) oversees the distribution of government funding for research through research councils (nine in total). The Australian Research Council (ARC) and National Health and Medical Research Council (NHMRC) perform similar roles in Australia.
- The UK and Australia use a dual funding system in which funds are allocated to institutions both through competitive grant processes and block grants.
- Both countries allocate a significant portion of their research funding through competitive grant programs, where researchers or teams submit proposals that are peer-reviewed and selected based on merit.
- Both systems have a dual support structure for research funding: one stream supports project-based research through competitive grants (responsive mode), and another stream provides funding to institutions based on their research income and quality of output (block grants).
- There are multiple research investors, and there is little evidence of serious coordination activity outside UKRI—for example with public research organisations and Ministry/Department mission-based research.
- There is extended use of criteria-based "research fund" arrangements that work outside the investment frameworks of the research councils.

Differences include:

- The UK's dual support system provides block grants to institutions based on the quality and volume of their research, as assessed by the Research Excellence Framework (REF). Australia's block grant programs[31] are less prominent and are calculated based on an algorithm that covers a mix of research income, publications, and completions of higher degrees by research.
- In the UK, post graduate research studentships are funded by UKRI which provide tuition and living stipend for students. In Australia, the Research Training Program provides a certain number of funded places to universities, which then allocate these to domestic postgraduate research students. Competitive living stipends are provided through a separate competitive funding scheme.

[31] The Research Training Program for supporting HDR students and Research Support Program for supporting research costs.

The UK's decision to leave the EU has impacted access to European research funding.

5.7 Australia and the United States

The Australian and US systems for funding higher education and government research are quite different.

As a Federation, the US R&D investment is heavily concentrated in several States, each with their own parallel research systems, specialisations, and research-intensive corporations. Information on the size of the R&D commitment in major research performing States is provided in Table 21.

Table 21: US expenditures for R&D for all performers, by state and source of funds: FY 2021

State	GDP ($US trillion)	GDP per capita	All R&D expenditure	Federal government	State and all others	State and all others (%) of total
California	3.50	89,540	523,819,635	28,494,592	495,325,043	94.6%
New York	1.90	96,502	417,246,309	166,507,446	250,738,863	60.1%
Texas	2.10	71,274	255,731,862	23,447,625	232,284,237	90.8%
Florida	1.30	59,046	178,360,429	25,068,596	153,291,833	85.9%
Pennsylvania	0.87	67,485	93,621,093	10,315,593	83,305,500	89.0%
Washington	0.69	90,034	56,690,210	17,162,043	39,528,167	69.7%
Ohio	0.77	64,941	55,336,431	8,732,356	46,604,075	84.2%
Connecticut	0.31	85,609	55,050,702	15,879,739	39,170,963	71.2%
Virginia	0.62	71,133	44,913,546	19,427,277	25,486,269	56.7%
Oregon	0.28	65,806	37,419,218	14,233,548	23,185,670	62.0%
North Carolina	0.69	64,885	36,870,713	11,005,615	25,865,098	70.2%
Michigan	0.59	58.935	29,718,391	6,912,826	22,805,565	76.7%
Massachusetts	0.66	95,029	23,307,621	6,047,993	17,259,628	74.1%
Illinois	0.97	76,825	16,213,542	7,152,110	9,061,432	55.9%
Wisconsin	0.38	64,436	15,239,075	5,893,866	9,345,209	61.3%
United States			2,471,471,226	612,123,519	1,859,347,707	75.2%

Source: NSF, Data tables, State government expenditures for R&D for all performers, by state and source of funds: FY 2021 and https://wisevoter.com/state-rankings/gdp-by-state/

Table 21 indicates the sheer size of the California, New York, and Texas research systems. The GDP of each exceeds Australian GDP in 2021 of $1.6 trillion. Table 21 also points to the significant contribution of State government and other funding sources to the State R&D effort. Information on the research system in California is provided below.

Comprehending Scale in National Research Systems—California (*not the US*)

California, with a population of 40 million, has *three* public university segments: the University of California System (UC) with ten campuses, five medical centres, and three national laboratories (annual budget $US40 billion)[32]; the California State University system (CSU) with 23 campuses (annual budget $US7 billion); and the California Community Colleges with 116 campuses (annual budget $US12 billion)[33]. Each of these systems, and institutions within them, have different missions.

[32] In 2016–17, externally funded research expenditures totalled $US4.6 billion at UC, with almost half coming from federal agencies. The National Institutes of Health (NIH) and the National Science Foundation (NSF) provided nearly three-quarters of UC's federal support.

[33] California also has more than 150 private not-for-profit colleges and about 160 for-profit institutions. These include Stanford University, California Institute of Technology (Caltech), University of Southern California (USC), Pepperdine University, Loyola Marymount University, University of San Francisco, Santa Clara University, University of San Diego, Claremont Colleges, Chapman University.

California Community Colleges (CCCs) appear to have some similarities with Australia's State TAFE systems. They provide a wide range of academic programs, vocational training, and workforce development initiatives designed to meet the needs of their local communities. They award associate degrees, certificates, and technical education credentials. Students can also transfer to four-year colleges and universities to complete their bachelor's degrees[34].

Of the 2.7 million students in California in 2018, 54% attended Community Colleges, 18% went to California State University, 12% to private not-for-profit, 10% to University of California, and 6% to private for-profit institutions.

It is also the case that not all is always well with international comparisons. The Public Policy Institute of California reported in 2019 that—

> Unlike most other states, California has not had a coordinating body for higher education over the past several decades. This has made goal setting, oversight, and coordination more challenging. The structure and principles established almost 60 years ago by the Master Plan for Higher Education remain largely unchanged. The Master Plan allowed the state's public system to accommodate dramatic increases in enrolment for several decades while providing broad access and charging little or no tuition fees. But over the past two decades, tuition [fees] have risen sharply, and enrolment has not kept up with demand. Current discussions and recent legislative efforts are moving the state towards re-establishing a higher education authority.

Issues concerning research system coordination were examined in Section 2.3 above.

Observation

9. **Differences in scale and scope may place constraints on what can be expected and what can be done and achieved when looking at international practice and experience. This is particularly the case when drawing analogies with the other Federations in the Study—USA, Canada, and Germany. In each of these countries the states/provinces/lander have a major role in delivery of higher education (sometimes exclusively) and in research. However, the national governments have a major role in research investment through national research foundations and councils.**

Most other US States have system universities: New York has two systems—the State University of New York (64 campuses), and the City University of New York (25 campuses); State University of Florida (12 universities); Pennsylvania State (14 universities); University of Texas System (14 institutions); University of Wisconsin (13 institutions).

[34] Each college within the California Community College system is locally governed and operated by its own elected board of trustees and administrative leadership team.

6 How Research Systems Feed into Broader Innovation Systems

This Section focuses on how research systems feed into the broader innovation systems, drawing attention to key differences with Australia.

6.1 Agencies and organisations

Each country, except the US, has an organisation with a specific focus on innovation. An overview of capacity and capability is provided.

Innovation agencies and organisations

Australia: Department of Industry, Science and Resources; Department of Education; Industry, Innovation and Science Australia (ISA)

Canada: Innovation, Science and Economic Development Canada (ISED); Canada Innovation Corporation—a mandate to increase Canadian business expenditure on R&D across all sectors and regions of Canada. Initial budget of $C2.6 billion over four years, starting in 2023-24

Germany: Federal Ministry for Economic Affairs and Climate Action (BMWi).

Israel: The Israeli Innovation Authority—a role to create, coordinate, and operate the national funding programs in industry; Korea Institute of Start-up and Entrepreneurship Development (KISED)

UK: InnovateUK—provides funding and support for innovative UK businesses

USA: The US does not have a national, coordinated innovation policy system, and does not generally support R&D directly in firms, unless that R&D is related to achieving a core mission, especially defence. However, extensive support is provided by National Research Institutes and Agencies.

6.2 Policies and programs

There is a great deal of variation in policies and programs, ranging from active to facilitative. Approaches vary from providing grants, venture capital, particularly seed funds (especially Israel), to facilitating connections and linkages between research organisations and end users, which is more the focus of the US National Institutes and Department of Energy and Defence.

In Federations States/Provinces/Lander also support innovation initiatives. A sample of innovation programs is provided in Table 22 below. It is apparent that the scope is extensive, but the coverage reported is by no means exhaustive.

Table 22: Profile of Innovation Programs

Country	Innovation Programs
Australia	Accelerating Commercialisation (through AusIndustry), CSIRO ON Program, ARENA Commercialisation of R&D Funding Pilot, The Medical Research Commercialisation Fund (MRCF), The Medical Device Fund, The Biomedical Translation Fund (BTF), CSIRO Innovation Fund, the NSW Commercialisation Grant Program and Commercialisation Pathways Program. Programs also operate in Victoria and Queensland. University Research Commercialisation Action Plan: provides funds for: Australia's Economic Accelerator, the Trailblazer Universities Program, the National Industry PhD Program, CSIRO Main Sequence Ventures, the Intellectual Property Framework.
Canada	Strategic Innovation Fund, which funds Business Innovation and Growth Projects and Collaboration and Networks Projects, Innovation Superclusters Initiative, the Invest Ottawa Scale-up Program. Canadian Technology Accelerators (CTA): CTA is a federal government program that provides Canadian startups and small and medium-sized enterprises with access to global markets. College and Community Innovation Program: provides innovative solutions for local and regional challenges faced by businesses, government, and communities, through the expertise of Canadian colleges, CEGEPs, and polytechnics. Ontario Centre of Innovation: a provincial government program that provides funding and support for innovation and commercialisation in Ontario.

Country	Innovation Programs
Germany	Central Innovation Program for SMEs, an inventory of programs is on the Federal Funding Database Many are EU initiatives. In addition: EXIST, a program to support university-based startups. High-Tech Gründerfonds: a public-private seed fund that provides financing to technology startups in a variety of sectors, including life sciences, engineering, and IT. Fraunhofer Venture: responsible for spin-off and investment management for Fraunhofer-Gesellschaft. Helmholtz Association Technology Transfer: The association's technology transfer program. Max Planck Innovation: responsible for technology transfer from the research institutes of the Max Planck Society. KIC InnoEnergy: a European innovation engine that supports sustainable energy innovation. Berlin Innovation Agency: a public-private partnership that supports innovation and entrepreneurship in the Berlin region. Leibniz Association Technology Transfer: The association's technology transfer programs. ZIM: an innovation program for SMEs, funded by the Ministry for Economic Affairs and Climate Action WIPANO: "knowledge and technology transfer via patents and standards".
Israel	An extensive range of Israeli Innovation Authority Programs is listed on the Authority's Website. Many involve international collaborations. For example, The Early-Stage Incentive Program.
Korea	The Korea Institute of Start-up and Entrepreneurship Development (KISED), BIRD Foundation: a joint initiative between the US and Israel that provides funding for joint research and development projects between US and Israeli companies, Technological Incubators Program: a government initiative that supports the development of technology startups in Israel. There are many specifically focused venture capital firms.
UK	Catapults and Innovation Centres, Scotland's Innovation Centre program and the Research Wales Innovation Fund (RWIF), Knowledge Transfer Partnerships (KTP), Industrial Strategy Challenge Fund (ISCF).
USA	The 2024 Budget Request includes funding for NSF Regional Innovation Engines (NSF Engines) ($300.0 million), Accelerating Research Translation (ART) ($45.0 million). NSF Convergence Accelerator ($100.0 million). In addition: The National Science Foundation's Engineering Research Centres (ERC), established in 1985 supports convergent research, education, and technology translation at US universities that will lead to strong societal impacts. The Small Business Innovation Research program and the Small Business Technology Transfer Programs which requires federal agencies to allocate a small share of their R&D budgets to small business research projects related to agency mission goals. The program was established in 1984. Industry-University Cooperative Research Centres (IUCRCs): IUCRCs are collaborative research centres that bring together academic researchers and industry partners to work on joint research projects. IUCRCs provide resources. National Institutes of Health (NIH) Office of Technology Transfer: The NIH Office of Technology Transfer is responsible for the commercialisation of inventions and discoveries made by NIH scientists. National Science Foundation (NSF) Innovation Corps (I-Corps): I-Corps is a program that provides training and funding for academic researchers looking to commercialise their technology. Department of Energy (DOE) Office of Technology Transitions (OTT): responsible for the commercialisation of technologies developed by DOE laboratories and scientists. National Institute of Standards and Technology (NIST) Technology Partnerships Office (TPO): The NIST TPO is responsible for the commercialisation of technologies developed by NIST scientists. They offer licensing, patenting, and funding services to help bring NIST technologies to market. Department of Defense (DOD) Defense Innovation Unit (DIU): DIU is a program that provides funding and support for innovative technology companies that have potential to benefit the DOD. National Aeronautics and Space Administration (NASA) Technology Transfer Program: responsible for the commercialisation of technologies developed by NASA scientists.

6.3 Innovation intermediaries and networks

An innovation intermediary is generally understood to be an independent third party that plays an integral part in collaborative activities supporting any aspect of the innovation process. They can act as an agent or broker in any aspect of the innovation process between two or more parties.

Intermediary activities include helping to provide information about potential collaborators, brokering transactions, acting as a mediator or 'go-between' between bodies or organisations that are already collaborating, and helping to find advice, funding, and support for the innovation outcomes of such collaborations.

Most countries have invested in Innovation Intermediaries and Innovation Networks, although some more than others. They can be supported by universities and public research organisations, government research organisations and government agencies. Some are based in Technology Transfer Offices, and others might be commercially oriented, either stand alone or connected with a professional services firm. A sample of profiles is in Table 23.

Table 23: Intermediaries in Innovation Systems

Country	Intermediaries
Australia	AusIndustry Innovation Connections—a key program for supporting collaboration between small and medium-sized enterprises (SMEs) and academic researchers. The newly formed Campus Plus, which offers on-demand Industry engagement; strategic partnership creation; researcher commercialisation training and mentoring; technology transfer; entrepreneurship training; unique IP identification, protection, development, and commercialisation.
Canada	The National Research Council of Canada Industrial Research Assistance Program (IRAP) provides funding, advisory services, and networking opportunities to small and medium-sized enterprises (SMEs) looking to innovate and grow. Mitacs, connects researchers in universities and colleges with industry partners. The Ontario Centre of Innovation (OCE) is a provincial innovation intermediary that connects researchers with industry partners to develop and commercialise new technologies.
Germany	Transferzentrum Mikroelektronik (TZM): An intermediary is based in Dresden and specialises in connecting researchers in the field of microelectronics with industry partners. Bayern Innovativ: based in Bavaria and focuses on promoting innovation and technology transfer in the region. Fraunhofer Venture, a subsidiary of Fraunhofer-Gesellschaft focuses specifically on technology transfer and commercialisation. Technology Transfer Initiative (TTI), based in Berlin and focuses on technology transfer and commercialisation in the life sciences sector. Innovation Alliance Berlin, an intermediary network of research institutions, start-ups, and industry partners in the Berlin area. TransferAllianz, an intermediary is based in North Rhine-Westphalia and provides support for technology transfer and commercialisation.
Israel	Start-Up Nation Central (SNC), a non-profit organisation that aims to connect international businesses with Israeli innovation; MATIMOP - The Israeli Industry Centre for R&D, a government organisation that promotes collaboration between businesses and academic researchers.
Korea	Korea Technology Transfer Centre, a government-supported organisation that promotes technology transfer and commercialisation in South Korea.
UK	Knowledge Transfer Partnerships (KTPs), with a mission is to connect ideas, people, and communities to respond to these challenges and drive positive change through innovation.

Many, less formal, intermediary arrangements have emerged in innovation districts and precincts, particularly in the USA. As discussed in Section 7, they perform an important *systems integration* role.

Observation

10. Several countries included in the Study have national intermediary organisations to facilitate making connections and collaborations between researchers and innovative SMEs. They include the National Research Council of Canada Industrial Research Assistance Program (IRAP), the Korea Technology Transfer Centre, and the UK Knowledge Transfer Partnerships Program. In Germany there are several intermediary organisations that focus on specific areas, such as microelectronics and the life sciences. Germany is in the process of setting up a new government Technology Transfer Agency, the German Agency for Transfer and Innovation (DATI). These initiatives provide a context for the Department of Education to consider support for the formation of a national technology transfer agency to focus specifically on the knowledge transfer and research commercialisation in the higher education sector. Such an agency would complement the work of existing university Technology Transfer Offices and develop new capability across the sector.

6.4 Technology transfer offices

Over the last 20 years, the number of Technology Transfer Offices has significantly increased due to increased funding for research and development and growing recognition of the economic and societal benefits of technology transfer.

Most are run within universities or research organisations, although Germany is setting up a new government Technology Transfer Agency, the German Agency for Transfer and Innovation (DATI).

Each country is a peak body that provides training, professional development, information and knowledge, and advocacy. The peak bodies for TTOs encourage membership from people involved in technology transfer, knowledge exchange, and commercialisation activities in academia, government, and industry.

A profile of the TTO infrastructure in each country is provided in Table 24.

Table 24: Numerical Profile of Technology Transfer Offices

Country	Number of TTOs	Peak organisation	Total Members (approximately)
Australia	50	Knowledge Commercialisation Australasia	700
Canada	70	AUTM (Canadian Chapter)	300
Germany	120	German Association for Technology Transfer and Innovation (DTI)	300
Israel	20	Israel Tech Transfer Network (ITTN)	500
Korea	30	Korea Technology Transfer Association (KTTA)	200
UK	120	Praxisauril	4,000
USA	400	Association of University Technology Managers (AUTM)	3,200
Totals	810		9,200

6.5 Universities as *places* for innovation urban development and renewal

Background

Universities are increasingly being recognised as *places* in Science, Research, and Innovation systems. The campus is a place for knowledge based interpersonal interactions and establishing trust-based connections between people in universities, public research organisations, VET providers, businesses, and governments.

- This place-based role connects strongly with public policy objectives concerning urban development and renewal. It creates a synergistic connection with universities interested in campus expansion and development, particularly to establish research facilities as a basis for attracting global research-intensive corporations interested in the science, research and innovation commitment and standing of the university.
- Across the globe massive urban renewal is taking place in cities, fundamental shifts in the nature of work and the workplaces they host, and transformation of outputs and consumption. *Cities compete* with one another to attract not only firms and direct foreign investment, but also skilled knowledge workers to develop their social capital and capacity for innovation.
- Location-based policy initiatives are concerned with generating knowledge spillovers. From an innovation effectiveness perspective knowledge spillovers explain both why geographical clusters of firms and innovative activity exist. Co-location allows these spillovers to be exploited and explains why some clusters perform better than others.

These observations suggest that the significance of innovation clusters, districts and precincts has become more nuanced than the economic geography thinking around agglomeration, and the urban and regional renewal initiatives that focus on upgrading urban services and infrastructure.

Investments in science, technology, and urban and regional infrastructure have the potential to build depth and scale, but the connections between actors must be global as well as local in their orientation.

Findings from the Study

The Study has found that national governments are developing policies to invest in and promote innovation clusters and districts. In Federations, policy initiatives also tend to come from State/Provincial/Lander Governments.

Some Governments, like Australia, do not have "policies" as such, but invest more on a speculative and opportunistic basis.

Policies, and approaches to cluster development, innovation districts and innovation precincts in the countries are outlined in Table 25.

Table 25: Place based policy initiatives

Country	Place-Based Policy Initiatives
Australia	Initiatives tend to actions rather than policy—for example, Western Sydney Aerotropolis, which is focused on advanced manufacturing and aerospace technology, and the Sydney Innovation and Technology Precinct, which is focused on the development of emerging technologies such as artificial intelligence and quantum computing.
Canada	The Innovation Superclusters Initiative aims to support industry-led innovation clusters in key sectors such as advanced manufacturing, agri-food, and digital technology.
Germany	The Cluster Excellence Program supports the development of world-class clusters in key industries such as automotive, aerospace, and energy; The Leading-Edge Cluster Competition aims to promote the development of world-class clusters in emerging industries such as bioeconomy, microelectronics, and photonics.
Israel	The Innovation Districts Program aims to establish innovation districts across the country, with a focus on urban areas.
Korea	
UK	The UK Innovation Corridor aims to establish a network of innovation districts and precincts across the country, with a focus on the "Golden Triangle" between London, Oxford, and Cambridge; The Government has a long-standing policy to support "Enterprise Zones"—there are currently 48 operating in England, with similar policies having been adopted by the devolved governments in

	Scotland, Wales, and Northern Ireland; The UK now has over 100 science parks—an umbrella term for research parks, technology parks, incubators, and innovation centres.
USA	The Regional Technology and Innovation Hubs supports the development of innovation clusters and ecosystems across the country. It is funded from the Chips and Science Act.

The Global Institute of Innovation Districts considers that, by conservative estimates, there are more than 100 innovation districts emerging around the world, although most of those identified are in the USA. Many districts combine SRI objectives with urban and development and renewal (property development) objectives.

Many “technology parks” are located adjacent to complex large scale manufacturing operations, particularly in large factory environments. Without a university presence, however, these places offer little scope for sustained innovation.

Observation

11. **Apart from Korea, all countries in the Study have place-based policy initiatives to support the development of innovation hubs, districts, and ecosystems. Many are targeted to support “cluster” developments, such as the Canadian Innovation Superclusters Initiative, the German Cluster Excellence Program, and the and US Regional Technology and Innovation Hubs initiative. Around the world, many identified innovation districts combine cluster objectives with urban and regional development and renewal (property development) objectives.**

7 Key lessons that international competitor funding systems could provide to inform policy development.

This Section brings together information captured in previous parts of the report that could assist in the processes of policy development, implementation, and review.

7.1 R&D investment targets

Several countries have targets to achieve 3%, or more, of R&D expenditure in GDP. The 3% of GDP target, often cited as a benchmark for R&D investment, was first proposed by the European Union in 2000 as part of its Lisbon Strategy to boost economic growth and innovation. It was renewed in 2010 under the Europe 2020 Strategy. Countries that have set a 3% target, or greater, for R&D investment as a percentage of GDP are listed in Table 26.

Table 26: International R&D Targets as Proportion of GDP and Performance

Country	Target	Currently
South Korea	5%	4.55%
Israel	4.25%	4.95%
Japan	4%	3.23%
Germany	3%	3.14%
Denmark	3%	2.72%
Finland	3%	2.76%
Sweden	3%	2.76%
Austria	3%	3.18%
France	3%	2.23%
Belgium	3%	2.47%
Estonia	3%	1.56%
USA	-	2.79%
Australia	-	1.79%
Canada	-	1.73%
UK	-	1.70%

Source: EU publications

Strategies to achieve targets have included—

- In 2010, the German Federal Government launched the "High-Tech Strategy 2020" and the "National Research Strategy BioEconomy 2030".
- South Korea launched the "Brain Korea 21" initiative in 1999. In 2014 the government also launched the "Three-year plan for Economic Innovation" as a part of its effort to secure the growth potential. In 2013, President Park launched the "creative economy" initiative, aiming to generate new jobs and markets through creativity and innovation, to strengthen the country's global leadership in the creative economy, and to promote creativity more generally in Korean society.
- In 2011, the Israeli government launched the "National Plan for the advancement of the Science and Technology Education System and in 2013 developed the "National Plan for the advancement of the Israeli Industry.
- In 1980 the Japanese government developed the "Basic Plan for Science and Technology" 2016-2020, to promote R&D investment and innovation and created the "New Energy and Industrial Technology Development Organisation" (NEDO).
- Denmark introduced the "Strategy for Denmark's Digital Growth", 2014 and the "Green Growth Strategy", 2012 to promote sustainable development and investment in green technology.
- In 2014, Finland developed the "Growth Strategy for Research and Innovation" and in 2008 launched the "Cleantech Finland" initiative.

- Sweden established Vinnova in 2001. The innovation strategy, titled "Sweden – a world-class innovation environment", was introduced in 2012.
- In 2016 Austria developed a comprehensive research and innovation strategy called "Innovative Austria 2020" and established the "Austrian Research Promotion Agency" (FFG).
- In 2013 France created a national research and innovation strategy, "France Europe 2020" which involved setting up several funding and support programs such as "Investment for the Future" and the "French Tech" initiative.
- In 2014 Belgium launched a national research and innovation strategy in the context of EU "Horizon 2020" and established several funding and support programs, such as the "Belgian Science Policy Office" (BELSPO), and the "Flanders Innovation & Entrepreneurship" agency.

During this time, Australia launched several national strategies—Backing Australia's Ability, 2004; Powering Ideas: an Innovation Agenda for the 21st Century, 2009; National Innovation and Science Agenda, 2015; and Australia 2030: Prosperity through Innovation in 2017. None of these had a target proportion of R&D expenditure in GDP.

There is a now a strong view in business and the research sector that Australia must invest substantially more in R&D—from the current 1.8% of GDP to 3.0%—an increase of two-thirds. But it is not sufficient to just argue that Australia must spend more on R&D—it is necessary to argue how such an increase would be funded, allocated and over what time frame in the context of new and revised policies, programs, and delivery frameworks that are fit for purpose.

Observation

12. **Three countries in the Study (Korea, Israel, and Germany have had a commitment to reach a target of expenditure on R&D of 3% of GDP. These countries have reached or exceeded the target. EU countries generally have adopted this target, although few have reached it. Reaching the target has been associated with clear research and development investment strategies and commitments, which have involved significant institutional strengthening. In Australia, reaching a R&D target of 3.0% of GDP will involve an increase in the current level R&D of two-thirds. However, the present devolved structure and fragmented landscape of research institutions and organisations is unlikely to be capable of delivering such a massive increase in the short-term. Innovative and transformational institutional frameworks would be required. In this context it is helpful to review research models overseas, and particularly in countries that have reached or exceeded the 3% target.**

7.2 Research policy issues concerning global research-intensive companies.

Business research investment is heavily concentrated in the areas of motor vehicles, pharmaceuticals, and technology. Companies that invest in these areas dominate the global 1,000 research-intensive companies. Many are in the countries covered by the Study, but specifically, the USA, UK, Germany, and Korea.

The German multinational Bayer, which is very active in Australian agriculture, invested $US6.19 billion in R&D in 2018, but none of this occurs in Australia. However, Bayer does recruit Australian PhD graduates to work in Germany.

Other chemical and pharmaceutical companies have very large R&D budgets, including Johnson & Johnson ($US11 billion R&D expenditure in 2018), Merk ($US10 billion), and Pfizer ($US8 billion). But very little of this is invested in Australia.

Similarly, multinational motor vehicle companies, with a substantial presence in the Australian market, invest little or no R&D in Australia. These include Volkswagen (global R&D spend in 2018 $US15.78 billion, Ford Motor Company ($US8.00 billion), General Motors ($US7.3 billion) and BMW ($US7.3 billion).

Technology companies with substantial sales activity in Australia, also do little if any R&D in Australia—including Microsoft (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).

Global R&D intensive companies do outsource aspects of their R&D investments. They simply can't do it all internally. However, the competition among countries for a slice of international corporate R&D investment is intense: companies have choices, and a major influence in that choice the availability of collaborative research infrastructure at higher education institutions public research organisations. An overview of that infrastructure is included in Table 8 on page 18 above.

- Many universities, public research organisations, and medical research institutes have taken an initiative to create this research infrastructure from their own resources (retained earnings, borrowing, and philanthropy), and *sometimes* State and Commonwealth Government grants—and business R&D investment and manufacturing activity has followed.
- The strategy has been followed in medical research and there are strong collaborations in bioscience hubs in Melbourne and Brisbane with global pharmaceutical companies, including the recent announcement by Moderna to establish a manufacturing plant on the Monash campus in Clayton.

Moderna manufacturing plant, Clayton

Located within the Monash Technology Precinct ... the facility will join a host of world-leading research and technology facilities already established in the precinct, including CSIRO, Australian Synchrotron, Victorian Heart Hospital, and Melbourne Centre for Nanofabrication.

The facility will be complemented by the Monash Centre for Advanced mRNA Medicine Manufacturing and Workforce training, which Monash is establishing in partnership with the Victorian Government[35].

[35] Breaking Ground: Moderna's big build begins, 7 December 2022.

Observation

13. **Global technology, motor vehicle and pharmaceutical companies invest heavily in R&D, and particularly in Germany, Korea, the UK, and the USA. Very little occurs in Australia. However, around the world, these companies collaborate with higher education institutions, but the competition to access this investment is tough. Australian Higher education research investment policy could be designed to encourage global technology, motor vehicle, and pharmaceutical companies to partner with Australian universities for greater commitment to R&D in Australia. This may be achieved through collaborations around major university owned research infrastructure facilities and equipment. Consideration may be given to policy that may support this investment directed towards a major expansion in the National Collaborative Research Infrastructure Scheme.**

7.3 Moving from "research as usual" to "breakthrough research”.

Australia, like many other countries in the Study, produces a very large number of research papers as measured by the Web of Science output metric (see Section 6 below and Data Attachments, Section 3). But only a small proportion have a high citation impact factor (CNCI) or are classified as highly cited. High citation rates are more likely to be associated with breakthrough research.

National research systems can sometimes be considered as trapped in a "research as usual" paradigm. This is by no means a universal observation, but the syndrome is often in play because of variety of factors. The most often identified are as follows[36]:

- Long established structures, processes, and priorities which may favour certain types of research—which can make it difficult for researchers to pursue new or unconventional approaches that may not fit within the existing framework of the research system. It may also be impacted by how research is recognised in publication opportunities and journal ranking systems.
- With scarce funding opportunities, the competition for funds is generally intense. This can lead to a focus on incremental, low risk projects that are more likely to receive funding, rather than pursuing more innovative or risky research that may have a higher potential payoff but a higher risk of failure.
- System organisation around traditional academic disciplines limit collaboration and innovation across disciplines—researchers may be more likely to pursue research within their own discipline, rather than seeking out interdisciplinary collaborations or pursuing research in areas outside their field.
- Researchers may be more likely to pursue research that fits within the norms and standards of their discipline and organisational unit, or that is more likely to be accepted for publication and generate high citation counts and career advancement—rather than pursuing research that challenges existing models or assumptions.
- Backgrounds, perspectives, and experiences of research leaders doctoral candidates which limit the range of ideas and approaches that are considered.

These issues, along with a wide range of matters relating to collaboration, culture, and risk, are not new and are widely acknowledged, but can continue unresolved for some time. The way they are played out and their intensity varies considerably.

[36] These observations rely on material accessed during the Study, together with insights gained from an extensive portfolio of projects and assignments undertaken over many years concerning Australia’s science, research, and innovation (SRI) system.

Observation

14. National research systems can sometimes be considered as trapped in a "research as usual" paradigm—research that fits with established norms and standards, is incremental, and low risk. Some countries included in the Study have taken steps to address the challenge of moving the research system from research as usual to breakthrough research through new national strategies and funding commitments associated with strong institutional frameworks that are capable of addressing "challenges" and "mission driven" research.

7.4 Towards *national challenges and mission driven* research

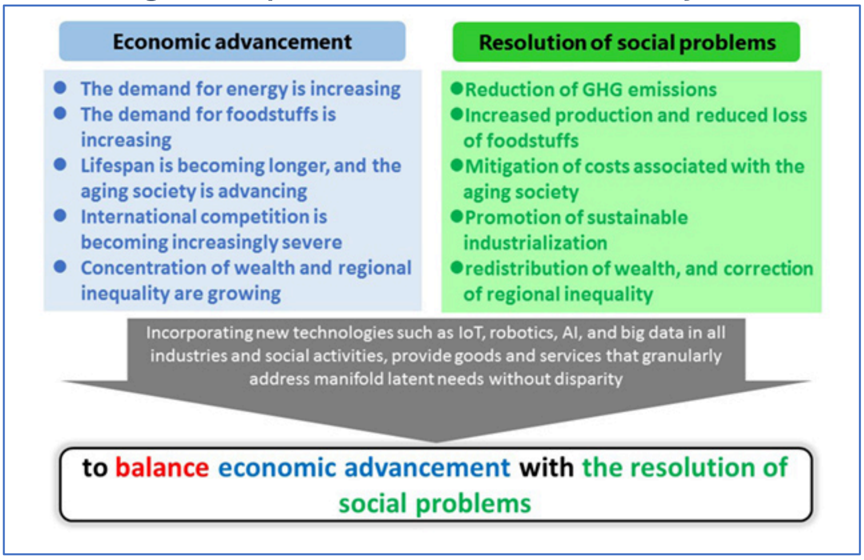
Mission driven approaches go much further than identification and public articulation of "research priorities".

Mission driven strategies set out to align research efforts with broader societal or national goals. This approach to research is becoming increasingly important among countries with active national research foundations.

- In 2022, the US National Science Foundation (NSF) announced a new strategic plan with a mission to promote the progress of science; advance national health, prosperity and welfare; to secure national defense; and for other purposes[37].
- The €95.5billion Horizon Europe program has adopted a mission-oriented approach in five areas: climate change, cancer, healthy oceans, climate-neutral and smart cities, and soil health and food, and has dedicated significant funding to each of these areas.
- UK Research and Innovation (UKRI) has adopted a mission driven approach that can address the UK government's "grand challenges," such as AI and data, clean growth, healthy ageing, and future of mobility[38]. UKRI has also launched several programs, including the Challenge Fund and the Strategic Priorities Fund, that promote interdisciplinary collaboration and address important societal challenges.
- The Japanese government has adopted a mission driven approach through its Society 5.0 initiative that balances economic growth with social and environmental sustainability. Priority areas include health and longevity, mobility, and disaster prevention and mitigation, and has dedicated significant funding to these areas.

[37] The 2022 NSF budget was $US8.8 billion. "NSF allocates 94% of its budget to research projects, facilities, and STEM education. NSF funds research in all states and U.S. territories - reaching 2,000 academic and other private and public institutions. ... NSF supports 24% of all federally funded research at academic institutions. On average, NSF receives approximately 43,000 grant proposals annually and funds about 12,000. NSF also supports innovation by small businesses, partnerships among academia, industry and national laboratories and research in non-profit non-academic organisations" (page 9).
[38] The UKRI Challenge Fund's future of mobility challenges aim to reduce the UK's carbon footprint from transport, reduce congestion and improve mobility through advancing technologies such as automation and robotics.

Figure 9: Japan's Research Mission: Society 5.0



Source: https://www8.cao.go.jp/cstp/english/society5_0/index.html

Adoption of mission driven strategies was a key recommendation of the Australia 2030: Prosperity Through Innovation Strategy.

7.5 National research strategies

Many countries have or are developing national research strategies, often in concert with science and innovation strategies. They can be all-encompassing or sector-specific.

- Canada does not have a national research strategy. Strategies are embedded in individual councils within the Innovation, Science and Economic Development and Health portfolios:

  National Research Council Canada (budget $C1.58 billion in 2021-22)
  Natural Sciences and Engineering Research Council ($C1.36 billion in 2022-23)
  Social Sciences and Humanities Research Council ($C1.02 billion for 2021-22)
  Canadian Institutes of Health Research ($C1.32 billion in 2021-22) within the Health Ministry.

  This is similar to a similar situation in Australia, although in Australia, responsibilities are split between the Department of Industry, Science and Resources (Science and Innovation) and the Department of Education (Research). Canada does not have a national Education Ministry.

- In Korea, national strategies are embedded in the Divisions of the National Research Foundation (Budget $US5.23 billion, 2019).

- A national SRI strategy for Israel cannot be located.

- Germany has recently instituted a *Pact for Research and Innovation* that aims to "strengthen the large non-university research organisations and the German Research Foundation by creating the stable financial conditions and freedom of movement needed by cutting edge research at the international level".

- Germany's Federal Ministry of Education and Research has also been realigning its research and innovation policy across all Ministries. It wants to "dare more progress in order to strengthen Germany's innovative power and secure Europe's technological sovereignty."

- In March 2023, the UK Government published the report of the Independent Review of the UK's Research, Development and Innovation Organisational Landscape, undertaken by Sir Paul Nurse. It arose from the UK Innovation Strategy: Leading the Future by Creating It, published in 2021. The Nurse Report points to:

  > The patchwork of Research Performing Organisations (RPOs) and research funders that comprise the UK's RDI landscape is the product of decisions taken over many years and reflects changing, sometimes short-term, public policy priorities and initiatives and varied approaches to public funding of research.

This reflects a similar problem in Australia, compounded by numerous plans and strategies announced over the last 20 years by both Commonwealth and State/Territory Governments that are disconnected, lack overall coherence, and have an effectively very short-term time horizon. This problem has been addressed in large measure with the University Research Commercialisation Package ($2.2 billion) and the National Reconstruction Fund ($15 billion), which have a legislated 10-year time horizon.

- In the US, research strategies are embedded in the recently authorised, which directs $US280 billion in spending over the next ten years. The Act, which is 1053 pages long, is very specific about the purposes, programs, and activities that will be funded.

  Scientific R&D and commercialisation ($US200 billion)
  Semiconductor manufacturing, R&D, and workforce development ($US52.7 billion)
  Tax credits for chip production ($US24 billion)
  Programs aimed at leading-edge technology and wireless supply chains ($US3 billion).

It may also be that developing an integrated science, research, and innovation (SRI) strategy is too big a task, given the failure of earlier approaches to gain traction.

Observation

15. **Several countries in the Study have taken steps to develop and deliver a national research strategy, including the German Federal Ministry of Education and Research *Future Research and Innovation Strategy*, which cuts across all Ministries. The United States *Chips and Science Act* has been a breakthrough in developing a research strategy for the USA, which took two years to negotiate. In 2021, the UK published *UK Innovation Strategy: Leading the Future by Creating It*. In line with these initiatives, the Australian Department of Education may consider a leadership role in collaborating with Departments to develop a national research strategy for Australia. The Strategy would focus specifically on research, acknowledging links to science, technology, and innovation systems.**

Addendum 1: Options for Institutional Strengthening in the Higher Education and Broader Public Research Systems

The study's main focus has been on Australia's higher education research system and international comparisons. In most countries covered in the Study, there is a high level of integration between the higher education research system and the government research system, which come together in a public research system.

This Addendum aims to draw together observations from practice in other countries to canvas some options for institutional re-alignment in the Australian higher education and government research systems—the public research system. These potentially desirable arrangements have not been evaluated against the criteria of practicality and feasibility in application to the Australian context.

Public research system framework

For its size, Australia has many disparate government research investor organisations, covering at least six ministries, two research councils, 15 R&D corporations/companies, various specific-purpose research funds, and committees.

Many State and territory governments also have research investment and delivery programs, the most significant of which are in the health and agriculture areas. However, the role of the Australian States and territories is much less than that of the other federations covered in the Study—Canada, Germany, and the USA.

As a result, the research investment system can appear disconnected and unsystematic, with the potential for duplication and overlap in some aspects of research and gaps in others.

While the system may be comprehended internally, there is a lack of external clarity about different and complementary roles and responsibilities and how the system's components interact and achieve results. A more systematic framework is required to address this concern.

Observation

16. **Notwithstanding Australian research capacities and abilities in multiple (mostly small) public research organisations across the research system, unlike Germany, Australia lacks a systematic framework for categorising and resourcing universities, government research organisations, laboratories, and research facilities. Such a categorisation could generate greater efficiency and effectiveness in the use of resources and contribute to enhanced research outcomes.**

A new research council for science, engineering, and technology

In both Canada and the UK, there is a research council with a specific mandate for supporting research in science, technology, and engineering fields of research. In Australia, there is a need for a strong researcher focus and commitment to information sciences and computing sciences to build on a small but high-performing research h base.

A new research council would focus on developing the knowledge, capabilities, and abilities for the industries of the future, specifically quantum information science, artificial intelligence, 5G, and advanced manufacturing. The council would complement the delivery orientation of the National Reconstruction Fund.

Observation:

17. **In The UK and Canada, designated research councils cover research investment in science, technology, and engineering. Consideration may be given to establishing a new research council for Australia with specific responsibilities relating to information and computing sciences and engineering, modelled on the proactive approach of the Canadian Natural Sciences and Engineering Research Council (NSERC)—with a strong linkage to national industrial strategy. The council would focus on quantum information science, artificial intelligence, 5G, and advanced manufacturing.**

Such an initiative would pick up features of the Canadian "tri-agency" framework—covering health (NHMRC), the ARC, and the new council. An extended option would be to give the ARC a specific remit in climate change, renewable energy, the environment, and social goals. As with the Canada First Research Excellence Fund and the New Frontiers in Research Fund, the councils would be encouraged to collaborate on funding cross-sectoral programs.

Such an approach would be more straightforward and deliverable within the Department of Education portfolio and the current higher education research system in the short-term. However, it would not deliver the potential benefits of a longer-term initiative to create an Australian National Research Foundation to drive the broader public research system.

Public research investment policy and operational advisory body (forum)

There is a general interest in establishing a new policy advisory body with broad stakeholder involvement to assist in prioritising and coordinating the work of the many investment and delivery agencies that constitute the Australian research system. Most of the countries covered in the Study have such an organisation.

Drawing on international practice, there are important design issues to address when creating such a body. These include—

- *Mandate and mission*: well-defined and understood by all stakeholders, covering roles in coordinating research activities, promoting collaboration among research institutions, and facilitating the dissemination and uptake of research findings.
- *Governance structure*: transparent, accountable, and representative of all stakeholders. There should be a board of directors/executive committee with diverse expertise, clear lines of authority, decision-making processes, and opportunities for general meetings of all participants.
- *Strategic planning and priority setting*: A strategic plan is essential. It would set out priorities and goals for research coordination and identify key areas of focus, informed by consultation with stakeholders and aligned with national research priorities.
- *Adequate funding and resources*: funds required to carry out its mandate and mission.
- *Effective communication and knowledge dissemination*: to address the need to connect effectively with constituencies, including promoting research findings, sharing best practices, and engaging stakeholders.
- *Collaboration and partnerships*: the ability to foster collaboration and partnerships among research institutions, government agencies, industry, and civil society to promote research excellence, innovation, and impact.
- *Institutional placement*: where the organisation would sit in a ministerial portfolio structure.

- *Membership*: whether predominantly or exclusively higher education and government research providers or wider inclusion of research investors and adopters of research outcomes.

Observation

18. Most countries have established or are contemplating the formation of research investment advisory councils with broad stakeholder involvement. In that context, consideration may be given to establishing a new Australian higher education research investment and delivery coordinating body to develop and articulate higher education research goals, provide expertise and advice on resource allocation, commission research, promote collaboration, and evaluate options for policy decisions. Most importantly, it would provide leadership in guiding the development and growth of the Australian higher education research system in a challenging and dynamic environment.

A policy coordination body would not preclude the possible assignment of *research investment and delivery* responsibilities to a *new research council*— see below.

A national research foundation

Germany, Israel, Korea, the USA, and many other countries not included in the Study have created national research foundations to drive strategy and resource allocation in public research. Drawing on international practice, the role of a foundation in an Australian context could be to—

- Develop a public research investment framework, national research strategy, and national missions.
- Prepare coordinated five-year financial plans, budgets, and allocation guidance.
- Promote high-quality research, ethical behaviours, and international collaboration.
- Builds engagement with governments, businesses, and the broader community.
- Supports knowledge transfer, translation, and commercialisation.
- Addresses major ongoing issues—low business R&D and improvements in research system architecture.

Observation:

19. Consideration should be given to developing a case for forming a National Research Foundation on the models of Germany, Korea, and the US. While such an initiative can be considered essential for Australia's long term research investment future, it is necessary to bear in mind that the process would be disruptive, involving major changes to the existing research investment infrastructure. An advantage of a National Research Foundation is to create the capability to deliver transformational change and secure Australia's future with research-driven economic growth.

What an Australian public research system might look like

Below is a synthesis of attributes of higher public research funding systems in the countries included in the Study. It covers both higher education research and government research in an integrated way.

Figure 10: What an Australian public research system might look like

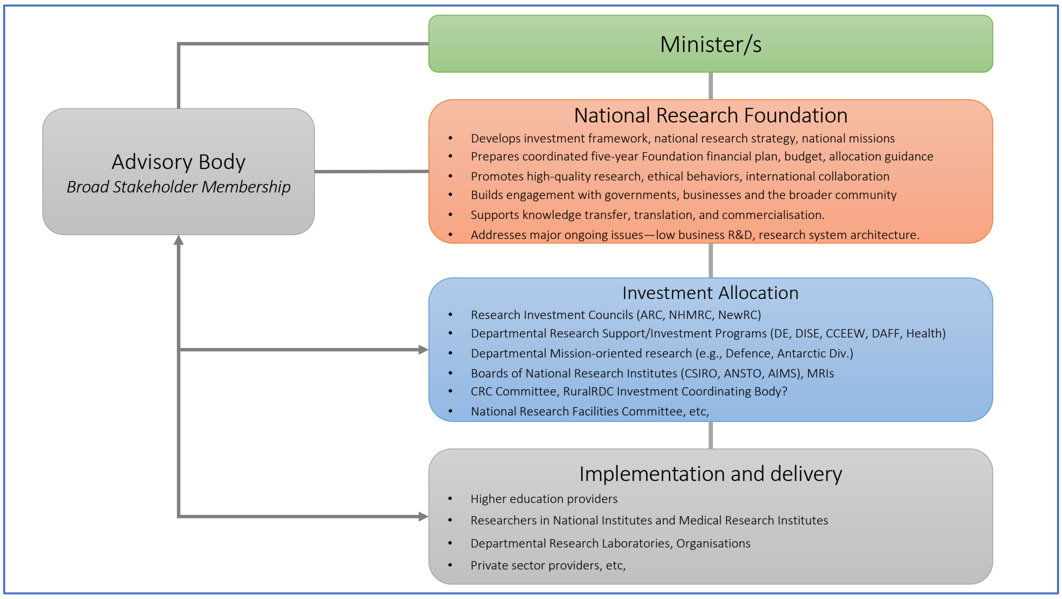


Figure 10 is presented as an "ideal" rather than a prescriptive formulation. Numerous caveats and qualifications would be required to make the framework work. Foremost among these is that the established institutional and resource allocation framework might prevent the introduction of a strategically driven body such as a National Research Foundation.

Attachment: Summary of Specific Observations and Findings

This Report contains several observations and some specific recommendations based on the study's investigations and findings. These are summarised below.

1. In comparison with other countries, and particularly Germany, the UK and the USA, Australia lacks a framework of permanent cross-sectoral collaborative research institutes and laboratories that support long-term research partnerships and collaborations between universities, governments, and industries. These frameworks have taken many years to create. Australia can achieve the many benefits of these frameworks by further developing the model of the "quasi-autonomous university research institute" established with strong support from Governments (Commonwealth and State) and industry to build long term and resilient university-industry research collaborations. Current applications of the model are at The Institute for Frontier Materials (Deakin), Sustainable Materials Research & Technology Institute (UNSW), the Queensland Alliance for Agriculture and Food Innovation (Brisbane) and the newly formed Sydney Quantum Academy.

2. Based on international comparisons, it cannot be said that Australia has too many universities. In fact, there is an argument for more technology-focused universities or for some, including NUHEPs, to become more technology-focused and research-focused. There is also a convincing argument for TAFEs to extend their strong engagement with industry into more applied research. There is also an argument for more diversity in the system, with smaller universities increasing their focus on the liberal arts.

3. The role of the Learned Academies in guiding research investment is often unrecognised. In other countries, particularly Germany, Korea, the UK and the USA, roles are very significant in terms of advice and research investments. Drawing on that experience, the knowledge, expertise, and capabilities embedded in the Australian Learned Academies must be effectively accessed and applied in the National Research System.

4. In all the countries covered in the Study, business-higher education collaboration organisations, such as the UK National Centre for Universities and Business (NCUB) and the Canada Business+Higher Education Roundtable (BHER), play an important role in promoting collaboration and partnership between universities and businesses. They provide a platform for dialogue, share expertise, and develop partnerships that can lead to the development of new technologies, products, and services. In Australia, key stakeholders may consider measures to strengthen the Australian Business-Higher Education Round Table using overseas practice as a guide.

5. Although most countries in the Study have strong commitments to knowledge transfer translation, there appears to be a limited commitment to research brokerage—creating knowledge by connecting researchers rather than translating or transferring it. It involves looking for and capturing potential knowledge spillovers in the research system to encourage breakthrough research. While peak bodies of the Learned Academies have important brokerage roles, particularly in Canada, Germany, the UK and the USA, the reach in Australia may be more constrained. Australia may benefit if more attention is paid to fostering research broker capability within the Learned Academies and professional institutes to further research collaboration in Australia and internationally.

6. Countries covered in the Study have developed strong capabilities in research intermediation to promote international cultural dialogue and academic exchange. These include the German Alexander von Humboldt Foundation (funding of €143m in 2019), Academic Exchange Service (DAAD), the EU Marie Skłodowska-Curie Actions Program, and the US Fulbright Program. Drawing on these experiences, the Department of Education may consider

extending its programs to build international researcher connections and networks at all stages of their careers.

7. Universities in all countries included in the Study can borrow to finance capital expenditure from banks, government agencies, and capital markets. Borrowings are generally subject to borrowing limits and regulatory requirements. Borrowing is easy for the larger metropolitan universities but is challenging for other universities. Some countries have pooled or established concessional borrowing arrangements that universities can access. There could be advantage in a review of mechanisms in Australia to more effectively pool or facilitate governance on borrowing arrangements for universities. The purpose would be to finance research facilities, particularly for smaller/regionally based universities that may not have the larger metropolitan universities' financial leverage (strong balance sheets and AA credit ratings).

8. The most significant level of support for R&D in the countries in the Study is tax credits, or "tax expenditures", provided through the taxation system. Tax credits may support university collaborative research investments under certain conditions. In 2019, Australian tax incentives (the RDTI) supported 13.4% of business expenditure on R&D, well below the UK's (26.4%). Despite the scheme being the most generous among OECD countries and costing $A2.4 billion, the OECD reports that Australian Business R&D has fallen from $US12.3 billion in 2009 to $US11.1 billion in 2019 (2015 Dollars Constant prices and PPP). Consideration may be given to reviewing the effectiveness of RDTI resources to provide more specific forms of research program support that foster higher education research collaboration.

9. Differences in scale and scope may place constraints on what can be expected and what can be done and achieved when looking at international practice and experience. This is particularly the case when drawing analogies with the other Federations in the Sudy—USA, Canada, and Germany. In each of these countries the states/provinces/lander have a major role in delivery of higher education (sometimes exclusively) and in research. However, the national governments have a major role in research investment through national research foundations and councils.

10. Several countries included in the Study have national intermediary organisations to facilitate making connections and collaborations between researchers and innovative SMEs. They include the National Research Council of Canada Industrial Research Assistace Program (IRAP), the Korea Technology Transfer Centre, and the UK Knowledge Transfer Partnerships Program. In Germany there are several intermediary organisations that focus on specific areas, such as microelectronics and the life sciences. Germany is in the process of setting up a new government Technology Transfer Agency, the German Agency for Transfer and Innovation (DATI). These initiatives provide a context for the Department of Education to consider support for the formation of a national technology transfer agency to focus specifically on the knowledge transfer and research commercialisation in the higher education sector. Such an agency would complement the work of existing university Technology Transfer Offices and develop new capability across the sector.

11. Apart from Korea, all countries in the Study have place-based policy initiatives to support the development of innovation hubs, districts, and ecosystems. Many are targeted to support "cluster" developments, such as the Canadian Innovation Superclusters Initiative, the German Cluster Excellence Programme, and the and US Regional Technology and Innovation Hubs initiative. Around the world, many identified innovation districts combine cluster objectives with urban and regional development and renewal (property development) objectives.

12. Three countries in the Study (Korea, Israel, and Germany have had a commitment to reach a target of expenditure on R&D of 3% of GDP. These countries have reached or exceeded

the target. EU countries generally have adopted this target, although few have rached it. Reaching the target has been associated with clear research and development investment strategies and commitments, which have involved significant institutional strengthening. In Australia, reaching a R&D target of 3.0% of GDP will involve an increase in the current level R&D of two-thirds. However, the present devolved structure and fragmented landscape of research institutions and organisations is unlikely to be capable of delivering such a massive increase in the short term. Innovative and transformational institutional frameworks would be required. In this context it is helpful to review research models overseas, and particularly in countries that have reached or exceeded the 3% target.

13. Global technology, motor vehicle and pharmaceutical companies invest heavily in R&D, and particularly in Germany, Korea, the UK, and the USA. Very little occurs in Australia. However, around the world, these companies collaborate with higher education institutions, but the competition to access this investment is tough. Australian Higher education research investment policy could be designed to encourage global technology, motor vehicle, and pharmaceutical companies to partner with Australian universities for greater commitment to R&D in Australia. This may be achieved through collaborations around major university owned research infrastructure facilities and equipment. Consideration may be given to policy that may support this investment directed toward a major expansion in the National Collaborative Research Infrastructure Scheme.

14. National research systems can sometimes be considered as trapped in a "research as usual" paradigm—research that fits with established norms and standards, is incremental, and low risk. Some countries included in the Study have taken steps to address th challenge of moving the research system from research as usual to breakthrough research through new national strategies and funding commitments associated with strong institutional frameworks that are capable of addressing “challenges” and “mission driven” research. 58

15. Several countries in the Study have taken steps to develop and deliver a national research strategy, including the German Federal Ministry of Education and Research Future Research and Innovation Strategy, which cuts across all Ministries. The United States Chips and Science Act has been a breakthrough in developing a research strategy for the USA, which took two years to negotiate. In 2021, the UK published UK Innovation Strategy: Leading the Future by Creating It. In line with these initiatives, the Australian Department of Education may consider a leadership role in collaborating with Departments to develop a national research strategy for Australia. The Strategy would focus specifically on research, acknowledging links to science, technology, and innovation systems.

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