Research Report – APRC-FY2022-RR-08

Asia and Pacific Research Center

Research Report on Science, Technology and Innovation Policy and R&D Trends in Australia

March 2024

Japan Science and Technology Agency

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This report is compiled as part of a research that surveyed and analyzed science and technology innovation policies, research and development trends, and associated economic and social circumstances in the Asia-Pacific region. It is being made public on the APRC website and portal site to enable wide use by policymakers, associated researchers, and people with a strong interest in collaborating with the Asia-Pacific region; please see the websites below for more details.

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Executive Summary

This study examines the science, technology and innovation (STI) partnership between Japan and Australia, with the aim of strengthening and deepening cooperation. The study includes an overview of Australia's STI landscape, relevant institutions and policies, and its relations with other countries in the context of STI.

Chapter 1 assesses Australia's baseline information, economic trends and performance in STI inputs (such as R&D expenditure), outputs (publications, patents) and outcomes (innovation indices, Nobel prizes, university rankings). This provides insights into Australia's strengths in STI.

Chapter 2 focuses on the structure and systems related to STI in Australia, providing details on key stakeholders, policy-making bodies, funding agencies and prominent research institutions. It provides a comprehensive overview of the country's approach to STI.

Chapter 3 provides a historical overview of Australia's STI policy and compares the goals and current state of the National Innovation and Science Agenda (NISA), which was introduced in 2015. It speculates on the direction of future policies up to September 2023, highlighting Australia's focus on its strengths and critical societal challenges.

Chapter 4 delves into the seven critical technologies announced in August 2022, detailing their importance, relevant policies, and the institutions or researchers leading the way in these areas. It highlights the importance of these technologies, particularly in defense and security, and the government's new initiatives related to them.

Chapter 5 provides an overview of multilateral collaborations such as QUAD and AUKUS, and bilateral partnerships, particularly with China and India. While traditional research collaborations have been with the US and the UK, there has been a growing momentum with China in recent years. However, the landscape may change due to the importance of the technologies mentioned above. In addition to the United States and the United Kingdom, with which Australia already has close relations, the government is proactively increasing its cooperation with India in various fields and is exploring new methods of research collaboration.

Chapter 6 outlines potential strategies to further strengthen STI cooperation between the two nations as Japan views Australia as a strategic partner, this chapter. Given the strong political and economic relationship, it proposes collaborative schemes and potential areas of cooperation, emphasizing security, societal challenges, and other emerging agendas.

In summary, the study provides a comprehensive understanding of Australia's STI landscape and suggests ways in which Japan can expand and deepen its cooperation with Australia in this field.

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1 Basic Information and STI Inputs, Outputs, and Outcomes in Australia

1.1 Basic Information

Chapter 1 provides an overview of Australia's research and development strength and competitiveness. Section 1 organizes basic information about Australia's geography, history, and economic trends as an introduction to the current situation in Australia. Section 2 investigates the inputs into research and development, revealing the trends and resources in Australian research and development. Specifically, it clarifies the funds invested in research and development by public institutions and private companies and organizes information on research and development expenditures and resources such as researchers. Section 3 organizes information on Australia's research outputs, such as publications and patents, revealing Australia's research achievements. It also organizes information on research trends in Australia and their impacts. The final Section 4 organizes information on the outcomes of Australia's STI and its international competitiveness, revealing Australia's position in the world from various perspectives, and introduces information on major domestic companies, technology-intensive companies, emerging businesses, and unicorns.

1.1.1 Social Trends

(1) Geographical Conditions

Australia's official name is the Commonwealth of Australia. It has a land area of about 7.69 million square kilometers, making it the sixth-largest in the world, roughly the same size as the United States, excluding Alaska, and about 20 times the size of Japan. The central lowlands are dry lands with little rainfall, and the western side has desert areas. Therefore, most major cities are concentrated in the eastern states and coastal areas, which have a temperate climate. The capital is Canberra, and the state and territorial capitals are Sydney, Melbourne, Brisbane, Perth, Adelaide, Hobart, and Darwin (Figure 1-1). Neighboring countries include New Zealand, Indonesia, East Timor, Papua New Guinea, etc.

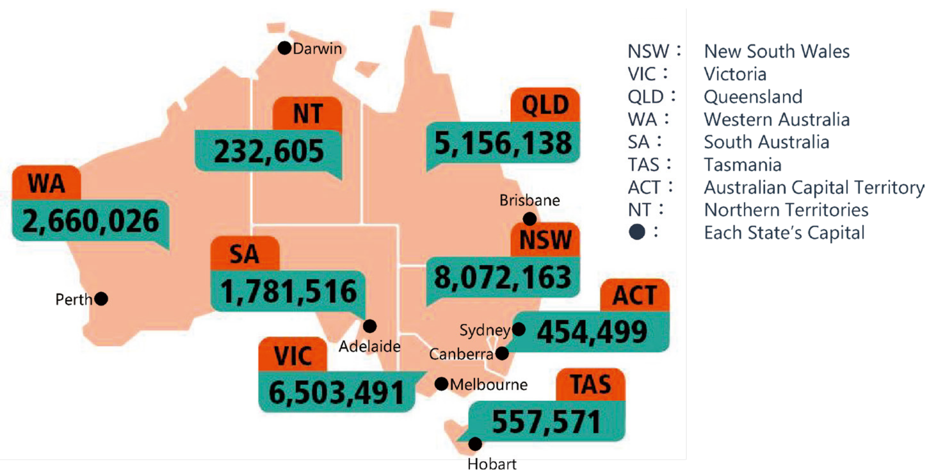


Figure 1-1 Population by State and State Capitals (2021)

Source: Created by the author based on the Australian Bureau of Statistics "Snapshot of Australia"

(2) Population[1]

Australia's population continues to grow, with the population in 2021 being 25.69 million, up from 17.28 million in 1991, an average annual increase of about 1.3% over about 30 years (Figure 1-2). Australia's population is concentrated in major cities, with 72% living in major cities. 26% live in the suburbs of Australia, with the remainder (about 2%) living in remote areas.

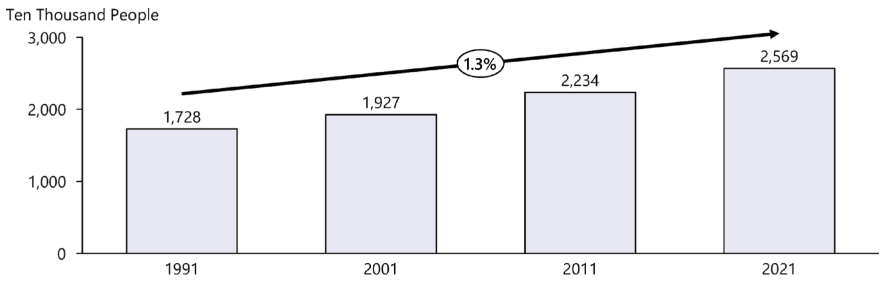


Figure 1-2 Population Trends

Source: Created by the author from the World Bank's databases

(3) Immigration

The largest factor supporting Australia's population growth is immigration. Australia actively accepts immigrants to grow its population (Figure 1-3). Their countries of origin are varied and include the United Kingdom, India, China, New Zealand, and Southeast Asia, etc. (Figure 1-4). As a result of actively accepting immigration, in the 2021 census, the ratio of citizens born overseas (first generation) or citizens whose parents were born overseas (second generation) was 51.5% of the total population, exceeding half for the first time[2].

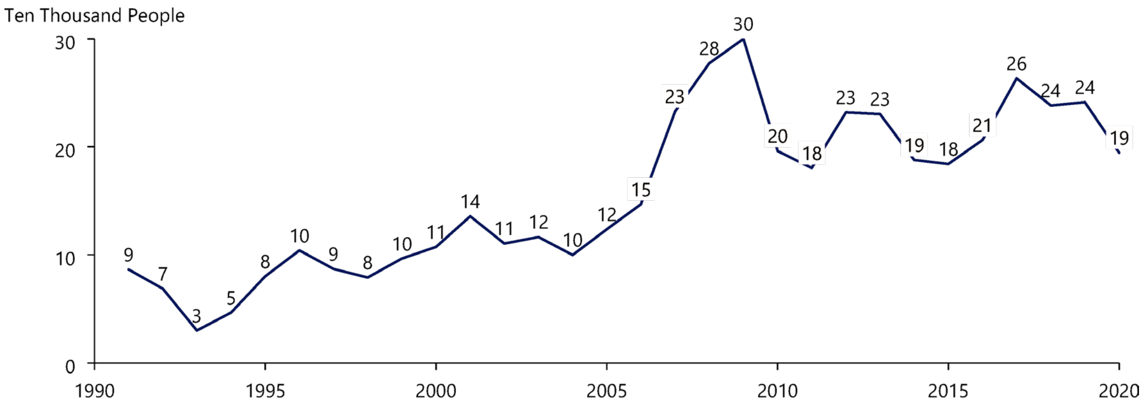


Figure 1-3 Net immigration trends

Source: Created by the author from the Australian Bureau of Statistics' "Migration, Australia"

1 Australian Institute of Health and Welfare, "Profile of Australia's population," accessed January 31, 2023. https://www.aihw.gov.au/reports/australias-health/profile-of-australias-population

2 Australian Bureau of Statistics "Story 14: The 2021 Census data," accessed January 31, 2023. https://www.abs.gov.au/census/about-census/delivering-2021-census/story-14-2021-census-data

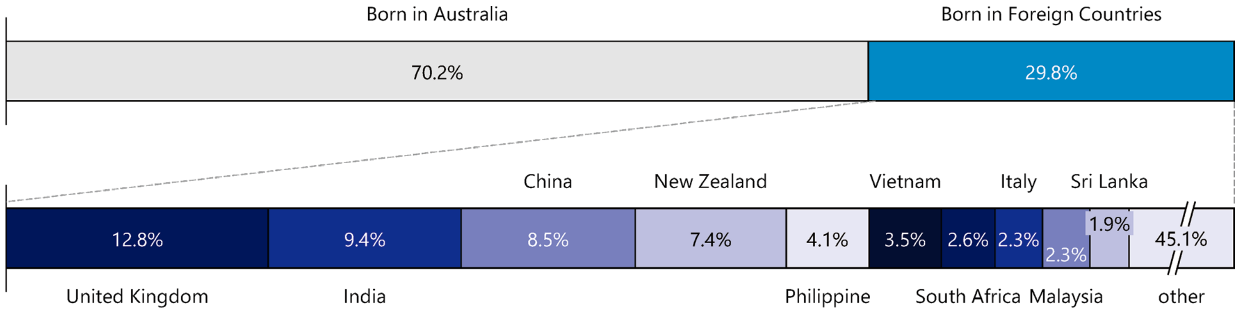


Figure 1-4 Population Composition by Country of Birth (as of June 30, 2020)

Source: Created by the author from the Australian Bureau of Statistics "Cultural diversity: Census"

(4) Ethnicity

With the increase in immigrants, there has been a change in the ethnic composition. Overall, those of European roots, including the United Kingdom and Ireland, are still prevalent, but those of Chinese ethnicity rank fifth (5.5%). Looking at the first generation alone, China (14.0%) is in second place, and India (8.3%) is in third place, suggesting that the ethnic composition will continue to change in the future (Figure 1-5).

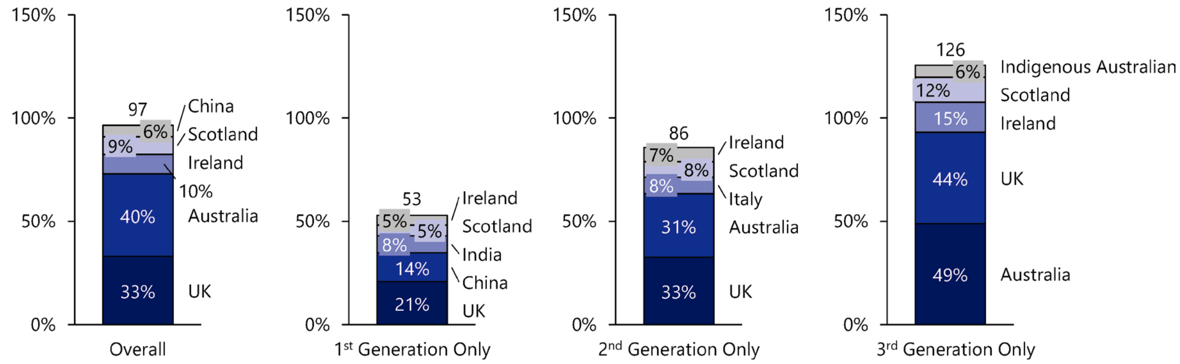


Figure 1-5 Ancestral Roots (2021)

Source: Created by the author from the Australian Bureau of Statistics "Cultural diversity of Australia"

(5) Religion

With the change in ethnic composition due to increased immigration, there has been a significant change in religious affiliation. Compared to 1996, the percentage of non-religious people has increased by 22 points, while the percentage of Christians has decreased by 27 points. It is assumed that immigrants from mainland China are included among those with no religion. Although still not a large percentage of the total, the absolute number of Muslims increased by about 610,000, Hindus by about 620,000, Buddhists by about 420,000, and Sikhs by about 200,000 from 1996 to 2021 (Figure 1-6).

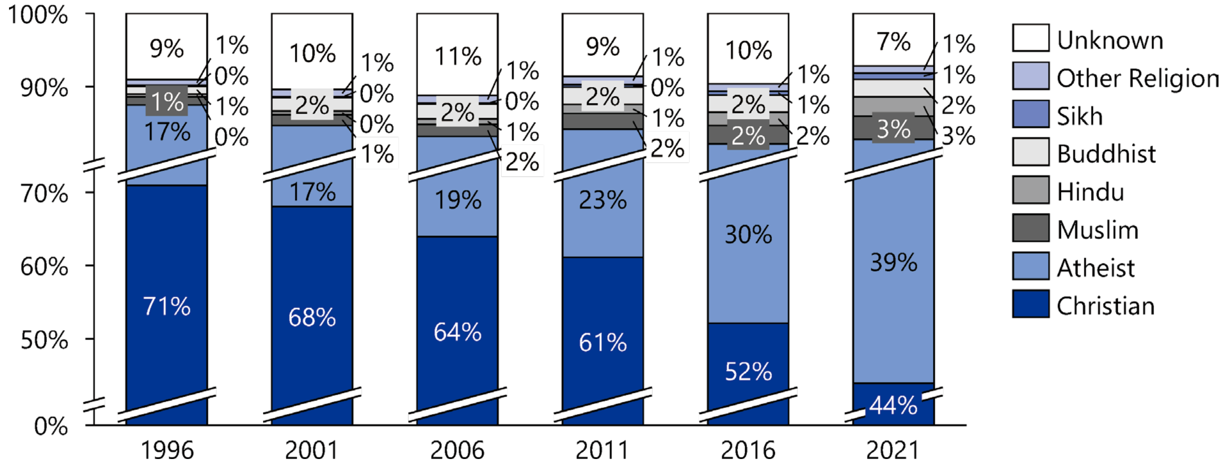


Figure 1-6 Religious Affiliation

Source: Created by the author from the Australian Bureau of Statistics "Cultural diversity: Census"

(6) History

Aboriginal Australians, the indigenous people of Australia, are said to have migrated from South Asia over 50,000 years ago, while the inhabitants of the Torres Strait Islands are said to have migrated to the islands of the Torres Strait, at the northern tip of Australia, from Melanesia about 10,000 years ago. Australia became a British colony in 1770, when the British explorer James Cook landed on the east coast of Australia and declared it a British territory. In 1788, a fleet led by British Navy Admiral Arthur Phillip anchored near Sydney Cove and began a settlement with about 1,350 crew members. Subsequently, the number of free settlers increased, and land was developed for cultivating crops and grazing. In 1797, Merino sheep brought by settlers from Spain made Australia one of the world's leading wool producers. In 1851, the discovery of gold in eastern Australia marked the beginning of the gold rush, and about 100,000 people from Britain, other European countries, and China migrated to Australia as mine workers. Thus, settlers from around the world laid the foundation of the Australian economy.

In 1901, the Commonwealth of Australia was established by integrating the six former colonies into states. After World War II, with rapid economic growth, restrictions on immigration in place since the gold rush were relaxed, and immigrants from Southern Europe began to be accepted again. These immigrants supported economic activities centered around mining, agriculture, and manufacturing. After the abolition of the immigration restriction laws in 1973, there was a surge in immigrants from Asia, and Australia formed into a multi-ethnic and multicultural nation[3].

(7) Political System

The Commonwealth of Australia is a federation consisting of six states and two territories . The national government, also known as the federal government, is responsible for national governance. However, the federal legislative authority is limited by the constitution to specific matters such as foreign affairs, defense, and currency, with other matters falling under the authority of the states. Therefore, the states and territories have considerable autonomy, and

3 Department of Home Affairs "A HISTORY OF THE DEPARTMENT OF IMMIGRATION, Managing Migration to Australia", https://www.homeaffairs.gov.au/about-us-subsite/files/immigration-history.pdf

the Australian government does not have legal authority to influence many of the decisions of the states and territories. The head of state of Australia is His Majesty King Charles III (Charles Philip Arthur George), the monarch of the United Kingdom. Under the Australian Constitution, executive power is exercised by the Governor-General, David Hurley, as the representative of the King. The Governor-General is appointed by the King on the advice of the Australian Prime Minister.

The parliament is bicameral, consisting of the Senate and the House of Representatives. The head of government in Australia is the Prime Minister. The Labor Party won the federal election in May 2022, leading to a change of government for the first time in 8 years and 8 months, with Anthony Albanese , the leader of the Labor Party, becoming the Prime Minister of Australia[4].

1.1.2 Economic Trends

(1) Industrial Structure

Like Japan, the tertiary sector accounts for about 70% of Australia's GDP, and the secondary sector accounts for about one-quarter of the GDP. Australian agricultural products are a competitive major export item, holding a 2.6% share of GDP compared to Japan's 1%. Focusing on gross value added (GVA) by industry, the mining sector accounts for 11%, financial services for 9%, and wholesale and retail trade for 9%, while technology-driven sectors such as professional, scientific and technical services, education, and IT account for 15% of the total economic production (Figure 1-7).

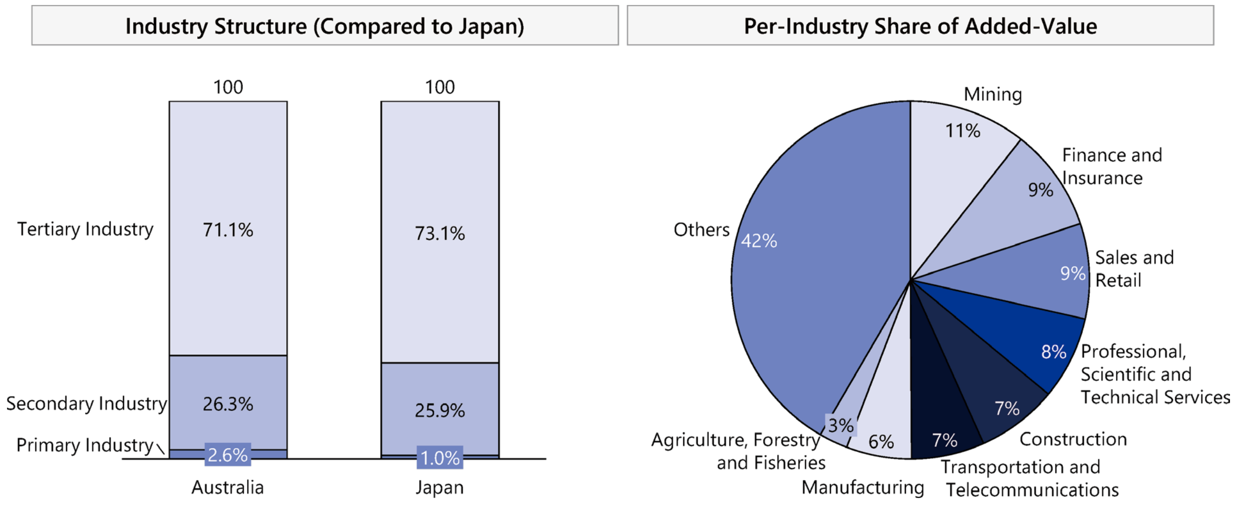


Figure 1-7 Industrial Structure (FY 2020)

Source: Created by the author from the Cabinet Office's Economic and Social Research Institute "Reference National Economic Accounts (GDP Statistics) Reference Material 3. Production (GDP by Industry)" and the Ministry of Foreign Affairs "Basic Data on Australia"

4 Department of Foreign Affairs and Trade "1. Introduction to Australia and its system of government," accessed January 31, 2023. https://www.dfat.gov.au/about-us/publications/corporate/protocol-guidelines/1-introduction-to-australia-and-its-system-of-government

(2) Economy

Despite the COVID-19 pandemic, which led to the closure of borders for most of 2020 and 2021, the Australian economy continues to grow, helped by rising prices for its resources (Figure 1-8). Additionally, its GDP is predicted to grow significantly by the end of 2022 compared to before the pandemic (2019), with the growth rate expected to exceed the average of advanced countries[5]. Along with economic growth, GDP per capita is also growing, reaching AUD 80,988 (about 7.2 million yen[6]) in 2021, significantly surpassing Japan's GDP per capita.

Australia is located close to the rapidly growing countries of Asia and has built good relations through trade and other means. Australia contributes to and benefits from the expansion of the Asian economy through exports, especially of minerals, energy, services, and agriculture, leveraging its abundant resources.

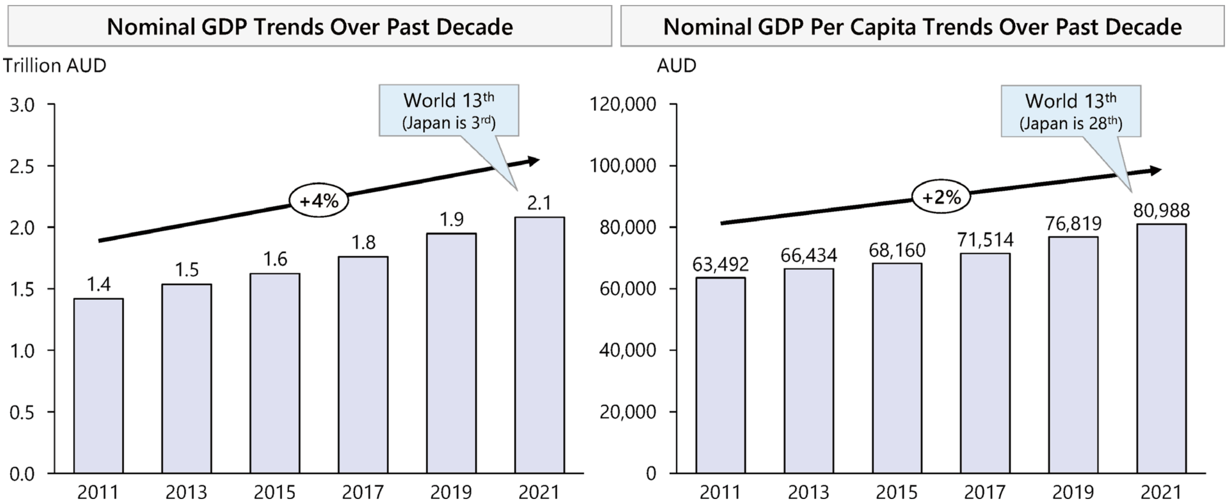


Figure 1-8 Trends in GDP and GDP per capita

Source: Created by the author from the World Bank's databases

(3) Trade Activities

Australia exports a large amount of resources on a monetary basis such as iron ore, coal, and natural gas. However, it also imports a variety of items, mainly those not produced domestically (Figure 1-9). In terms of trading partners, China, the United States, and Japan rank high in both exports and imports. However, China's presence is particularly prominent, accounting for over one-third of exports and just under one-quarter of imports (Figure 1-10).

5 AUSTRADE, "Why Australia Benchmark Report 2022," accessed January 31, 2023. https://www.austrade.gov.au/benchmark-report/fundamentals/fundamentals

6 1 AUD = 87.24 yen (as of March 28, 2023)

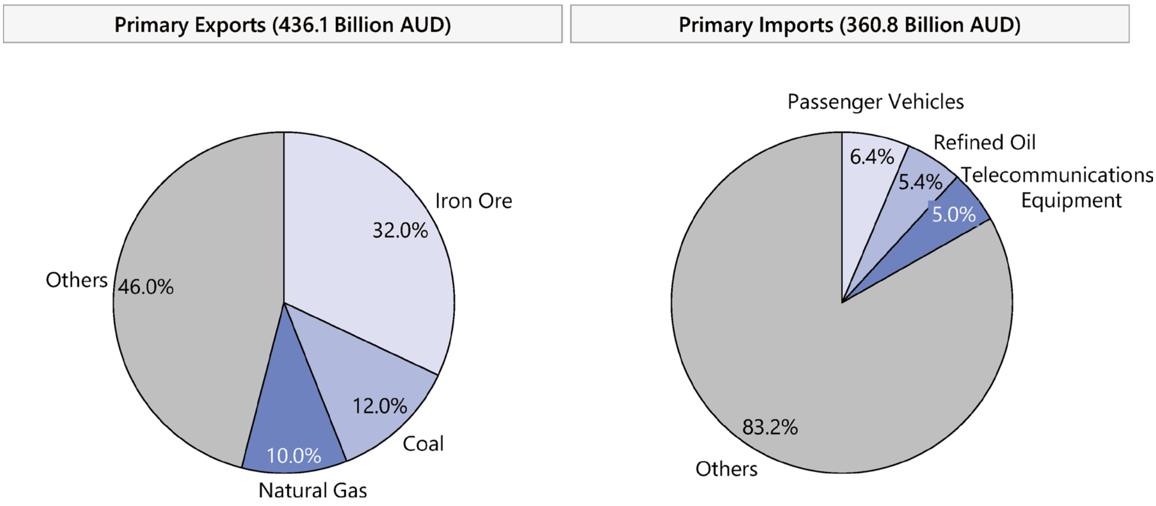


Figure 1-9 Trade Items (2020)

Source: Created by the author from the Ministry of Foreign Affairs' "Basic Data on Australia"

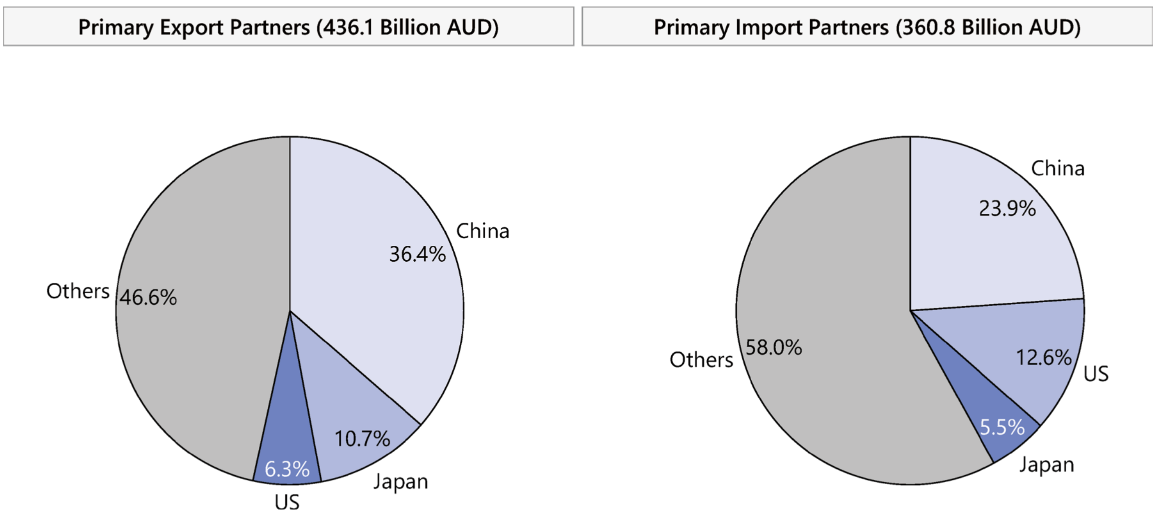


Figure 1-10 Trading Partners (2020)

Source: Same as Figure 1-9

(4) Gini Coefficient

The Gini coefficient[7], an indicator for assessing income disparity and understanding inequality in society, is higher compared to Nordic countries such as Finland and Denmark, but lower when compared with the United States, the United Kingdom, and Japan. Although there has been a slight increase compared to 2000, the disparity has not significantly widened over the long-term (Figure 1-11).

[7] An index indicating the disparity in income distribution among individuals. Between 0 and 1, where closer to 0 indicates smaller income disparity, and closer to 1 indicates larger disparity.

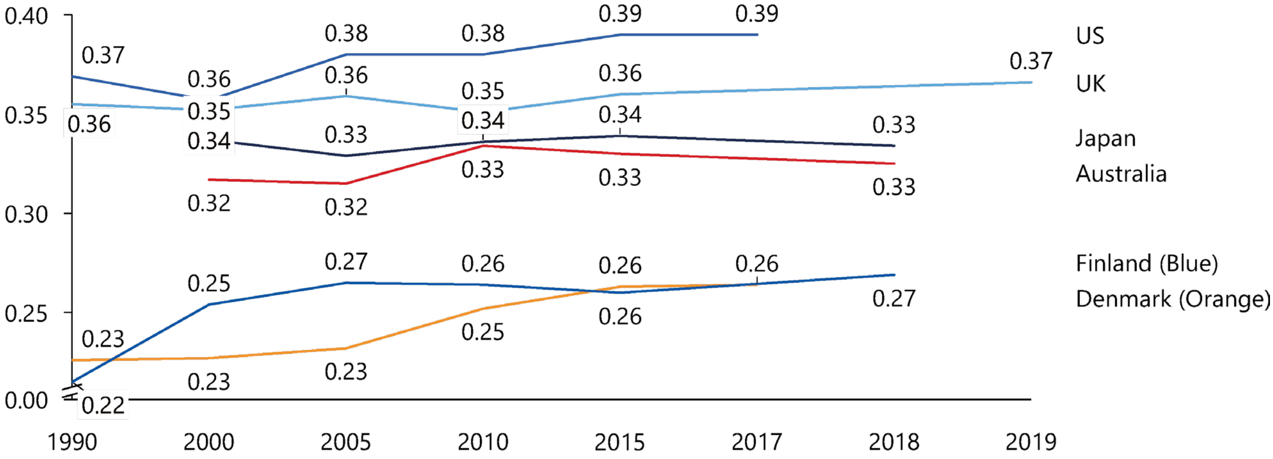


Figure 1-11 Gini Coefficient

Source: Created by the author from the Japan Institute for Labor Policy and Training "Data Book of International Labour Statistics 2022"

(5) International Competitiveness of Domestic Companies

According to Forbes' "Global 2000" ranking in 2022, Australia has 30 companies among the world's leading 2000 companies. It has eight companies each in the financial and resources sectors, indicating their international competitiveness (Table 1-1).

Table 1-1 List of Australia's Global 2000 Companies (2022 edition)

#	Ranking	Company Name	Industry
1	75	BHP Group	Resources
2	107	Commonwealth Bank	Banking & Finance
3	174	Westpac Banking Group	Banking & Finance
4	192	ANZ	Banking & Finance
5	199	National Australia Bank	Banking & Finance
6	312	Macquarie Group	Banking & Finance
7	371	Fortescue Metals Group	Resources
8	374	Woolworths	Agriculture & Food
9	547	CSL	Pharmaceuticals & Biotechnology
10	559	Wesfarmers	Agriculture & Food
11	597	Telstra	Telecommunications
12	786	Woodside Petroleum	Resources
13	836	QBE Insurance Group	Insurance
14	901	Coles Group	Agriculture & Food
15	957	Suncorp Group	Insurance
16	1021	Goodman Group	Construction
17	1231	Santos	Resources
18	1236	BlueScope Steel	Resources
19	1308	Transurban Group	Transportation
20	1356	South32	Resources
21	1372	Sonic Healthcare	Healthcare
22	1490	Newcrest Mining	Resources
23	1552	Centaur Group	Banking & Finance
24	1557	Atlassian	IT Software and Services
25	1715	Ramsay Health Care	Healthcare
26	1794	Bank of Queensland	Banking & Finance
27	1811	Bendigo and Adelaide Bank	Banking & Finance
28	1924	Dexus	Banking & Finance
29	1944	Aristocrat Leisure	Consumer Goods
30	1976	Ampol	Resources

Source: Created by the author from Forbes "The Global 2000"

1.2 Information on Inputs Related to STI

This section organizes the definitions of research and research and development stages in Australia. It then investigates the trends in research and development expenditures in Australia, revealing the amounts that public institutions and private companies are spending on research and development and the fields they are spending in. It also assesses information on allocations of researchers by sector and major organization, organizing the distribution of resources in the country.

1.2.1 Research and Development and its Stages

(1) Definition of Research and Development

Although there are multiple definitions of research and development (R&D), the Australian Bureau of Statistics adopts the OECD manual's definition[8], "comprise creative and systematic work undertaken in order to increase the stock of knowledge–including knowledge of humankind, culture, and society–and to devise new applications of available knowledge." To be recognized as research and development, it must meet all five of the following criteria: (1) be novel, (2) be based on original concepts or hypotheses, (3) have an uncertain outcome, (4) be planned and budgeted, and (5) lead to reproducible results.[9]

(2) Stages of Research and Development

Although there are multiple definitions of research and development stages, the Australian Bureau of Statistics divides them into four: pure basic research, strategic basic research, applied research, and experimental development. The definitions of each are as follows.

8 Australian Bureau of Statistics "Australian and New Zealand Standard Research Classification (ANZSRC)," accessed January 31, 2023. https://www.abs.gov.au/statistics/classifications/australian-and-new-zealand-standard-research-classification-anzsrc/latest-release

9 OECD, "Frascati Manual 2015 Guidelines for Collecting and Reporting Data on Research and Experimental Development", https://www.oecd.org/innovation/frascati-manual-2015-9789264239012-en.htm

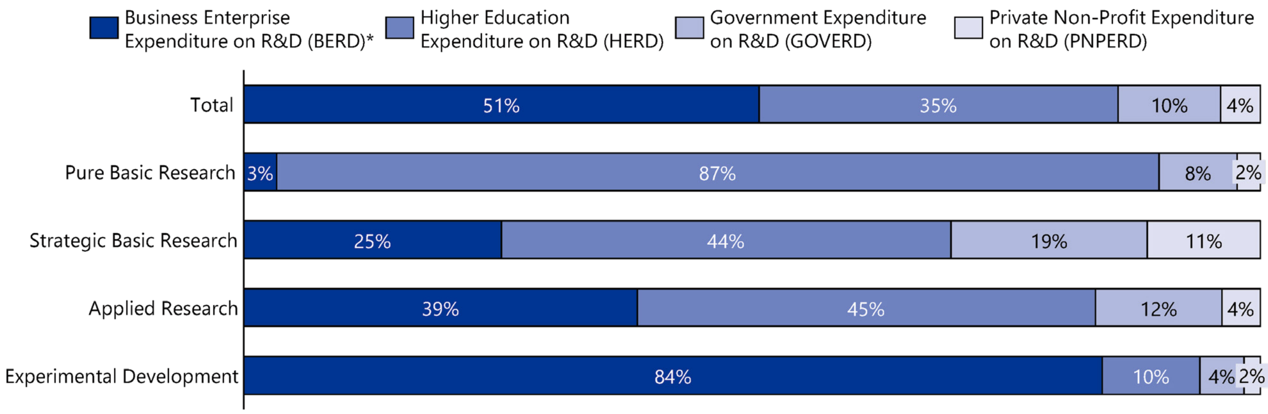
Table 1-2 Definition of Research and Development Stages

Stage	Definition	Original Definition
Pure Basic Research	Experimental and theoretical research conducted to acquire new knowledge without seeking long-term benefits other than the advancement of knowledge.	Pure basic research is experimental and theoretical work undertaken to acquire new knowledge without looking for long term benefits other than the advancement of knowledge.
Strategic Basic Research	Experimental and theoretical research conducted to acquire new knowledge directed towards a specific broad area where useful discoveries are expected. Strategic basic research provides a broad base of knowledge necessary to solve recognized real-world problems.	Strategic basic research is experimental and theoretical work undertaken to acquire new knowledge directed into specified broad areas in the expectation of useful discoveries. It provides the broad base of knowledge necessary for the solution of recognized practical problems.
Applied Research	Unique research primarily conducted to acquire new knowledge with specific applications in view. Applied research is conducted either to determine how to use the results of basic research that are in a usable form or to find new methods to achieve specific and predetermined goals.	Applied research is original work undertaken primarily to acquire new knowledge with a specific application in view. It is undertaken either to determine possible uses for the findings of basic research or to determine new ways of achieving some specific and predetermined objectives.
Experimental Development	Systematic research using existing knowledge derived from research or practical experience aimed at producing new materials, products, devices, introducing new processes, systems, services, or significantly improving those that are already being produced or introduced.	Experimental development is systematic work, using existing knowledge gained from research or practical experience, that is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

Source: Created by the author from "1297.0 - Australian Standard Research Classification (ASRC), 1998" by the Australian Bureau of Statistics

(3) Research and Development Expenditure

In Australia, about half of the research and development costs are borne by the private sector, about one-third by higher education institutions, one-tenth by government agencies, and a small portion by the non-profit sector. Examining each stage of research and development, universities pay for nearly 90% of pure basic research, with government agencies covering just under 10%. In strategic basic research and applied research, universities cover nearly half, followed by businesses and government agencies. However, the private sector covers more than 80% of experimental development (Figure 1-12).

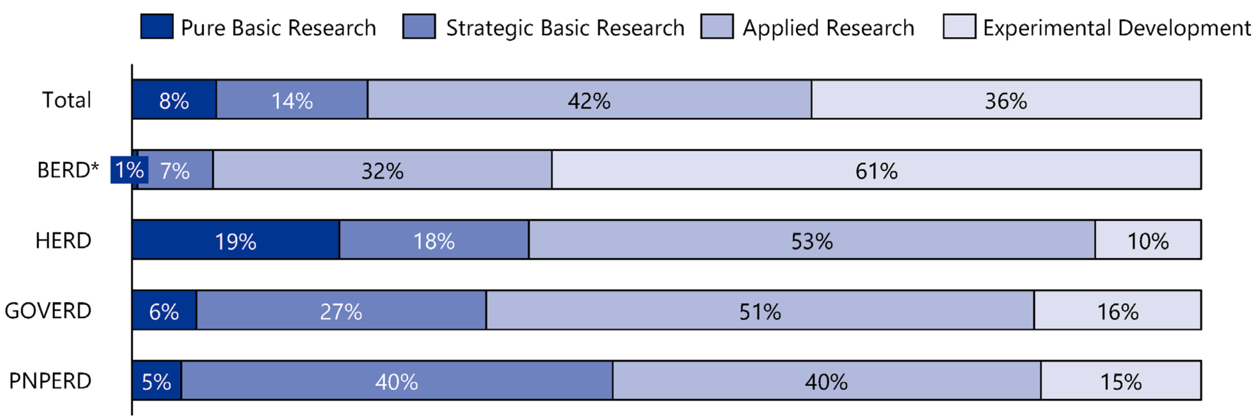


*Note: Due to the unavailability of 2020 data for the private sector, 2019 data has been used.
2020 data has been used for the rest.

Figure 1-12 Breakdown of Research and Development Expenditure in Australia (by Research and Development Stage)

Source: Created by the author from "Research and Experimental Development, Businesses, Australia," "Research and Experimental Development, Government and Private Non-Profit Organisations, Australia," and "Research and Experimental Development, Higher Education Organisations, Australia" by the Australian Bureau of Statistics

Examining the expenditure trends of each sector, applied research accounts for the most at just over 40%, experimental development at just under 40%, strategic research at just over 10%, and pure basic research at just under 10% overall. In the private sector, about 60% is for experimental development and about 30% for applied research, with expenditure on basic research being limited. Higher education institutions pay for than 50% of applied research, which is the highest, but compared to other sectors, they also pay for more pure basic research and less experimental development. The government and non-profit sectors have a higher ratio of strategic basic research expenditure compared to the private sector and higher education institutions, even though their expenditure in applied research is also significant (Figure 1-13).



*Note: Due to the unavailability of 2020 data for the private sector, 2019 data has been used.
2020 data has been used for the rest.

Figure 1-13 Breakdown of Research and Development Expenditure in Australia (by Sector)

Source: Same as Figure 1-12

Comparing the expenditure ratios of each sector in Japan, differences with Australia can be observed. In Japan, experimental development accounts for the majority at two-thirds, and the ratios of basic and applied research are lower compared to Australia (Figure 1-14). There are two main reasons for the differences between Japan and Australia: one is that the ratio of experimental development costs to research expenses in the private sector in Australia is 61%, which is about 15 points lower than in Japan, and the other is that the proportion of the private sector in total research expenses in Australia is about 50%, which is less compared to Japan (about 80%), indicating a weaker influence of the private sector on research expenses. Focusing only on universities, the ratio of basic research in Japanese universities is 54%, higher than Australia's 37% (combined pure basic and strategic basic research).

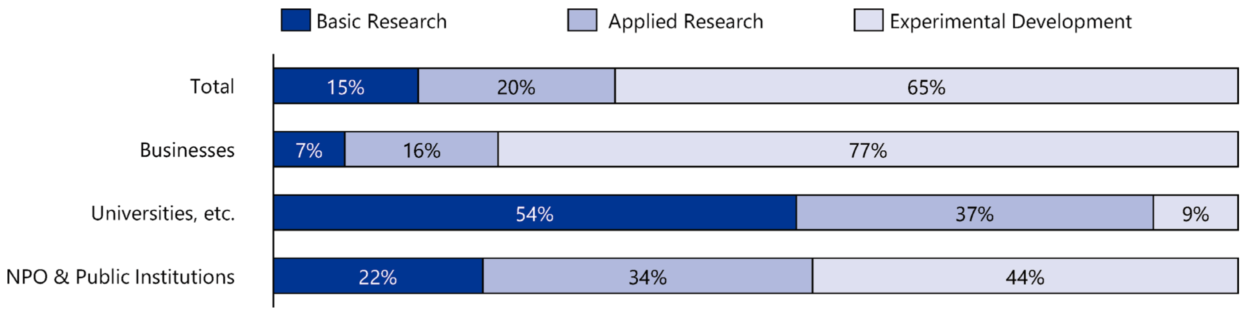


Figure 1-14 Breakdown of Research and Development Expenditure in Japan (by Sector)

Source: Created by the author from "Statistics on Japan's Science and Technology Research (May 2022)" by the Ministry of Internal Affairs and Communications Statistics Bureau

Although difficult to strictly categorize, taking the above into account, the main research institutions and research funding agencies at each stage of research and development in Australia and Japan can be broadly organized as follows (Table 1-3).

Table 1-3 Main Research Institutions and Research Funding Agencies by Research and Development Stage

		Research Stage				
		Pure Basic Research	Strategic Basic Research	Applied Research	Experimental Development	Industrial Development
Australia	Main Research Institutions	Universities	Universities, Businesses, Public Research Institutions	Universities, Businesses, Public Research Institutions	Businesses	Businesses
	Main Funding Agencies	FAs such as the ARC	FAs such as the ARC, Government (DISR etc.)	Same as on left	Government (DISR etc.), Businesses	Businesses
Japan (Reference)	Main Research Institutions	Universities	Universities, National Research and Development Agency (National Research Institutes)	National Research Institutes, Universities	Businesses, Technological Research Associations, National Research Institutes	Businesses
	Main Funding Agencies	Japan Society for the Promotion of Science	Japan Science and Technology Agency, NEDO	NEDO	Businesses, NEDO	Businesses

Source: Created by the author based on interviews, desk research, etc.

Next, examining the expenditure on research and development (GERD: Gross domestic expenditure on R&D) in Australia reveals that it has grown 3.6 times in 2019 compared to 2000. However, growth has been flat since 2011 due to research and development expenditure, which was exceeding 2% of the GDP, falling below 2% in recent years. Even though the percentage of research and development expenditure in GDP has fallen, the country's GDP has been growing, thus it is maintaining and expanding GERD (Figure 1-15).

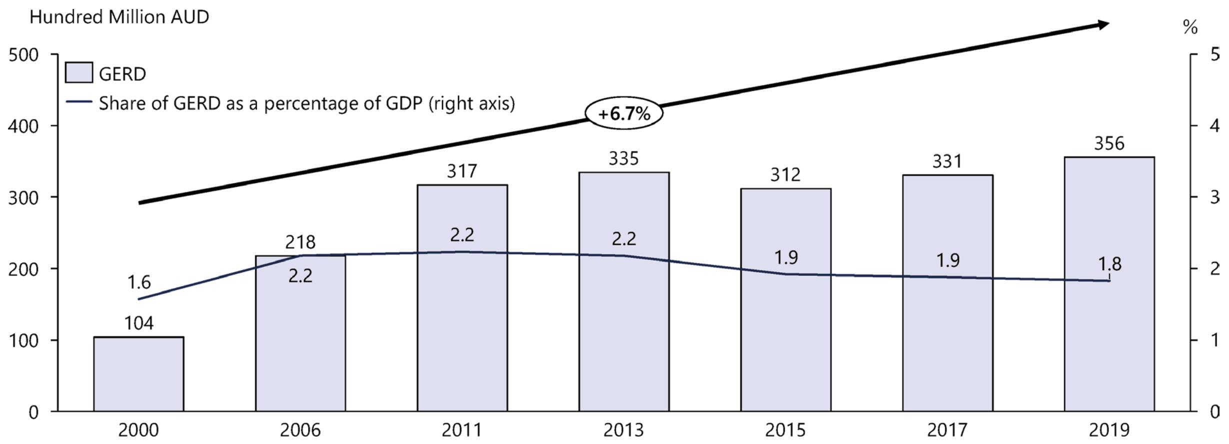


Figure 1-15 Trends in GERD and GERD as a Percentage of GDP

Source: Created by the Author based on the World Bank's databases and UNESCO's Institute for Statistics

1.2.2 Trends in Research and Development by Organization

(1) Private Sector & Corporate Research and Development Expenditure

In fiscal year 2019, private sector R&D spending (BERD: Business expenditure on research and development) amounted to approximately 18.1 billion AUD, representing 0.9% of the Gross Domestic Product (GDP). This ratio is unchanged from the previous year.

The main areas of research and development expenditure in the private sector are information & computing sciences (39%), engineering (29%), and biomedical & clinical sciences (12%), with the top 10 areas detailed as follows (Figure 1-16).

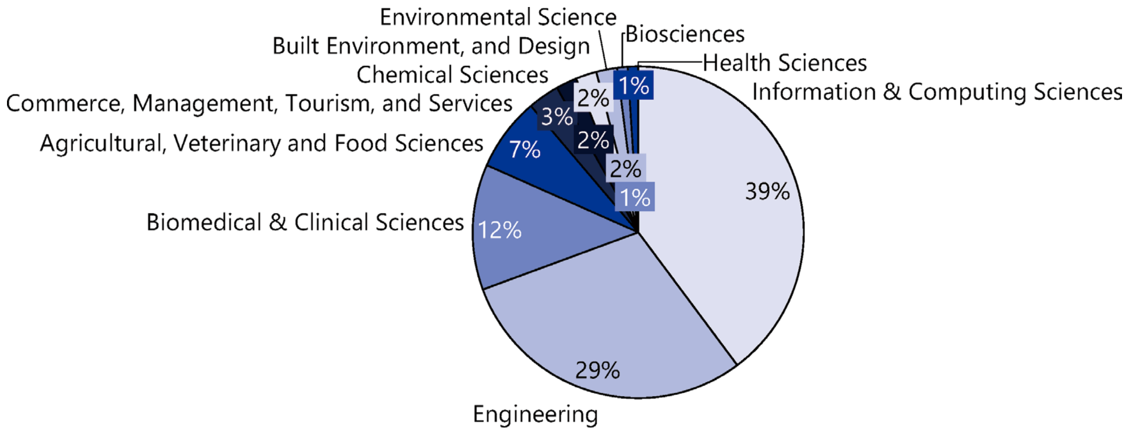


Figure 1-16 Top 10 Areas of R&D Expenditure in the Private Sector (2019 Fiscal Year)

Source: Created by the author from Australian Bureau of Statistics' "Research and Experimental Development, Businesses, Australia"

The primary objective of research and development expenditure in the private sector is the commercialization of technology, with a focus on demonstrative research that can be monetized or commercialized. However, basic research constitutes less than 10% of the total. In 2021, the top three Australian companies with the highest research and development spending were CSL Ltd. (pharmaceuticals & biotechnology), Telstra (technology hardware & equipment), and the Commonwealth Bank (banking), with expenditures of 1.6 billion AUD, 900 million AUD, and 700 million AUD, respectively[10].

(2) Higher Education Institutions' Research and Development Expenditure

In fiscal year 2019, R&D spending by Australian higher education institutions (HERD: Higher education expenditure on research and development) was 12.6 billion AUD. The percentage of GDP accounted for by this expenditure slightly decreased from 0.62% to 0.61%. The main reason for the decrease in research and development expenditure was the decline in tuition fee income from international students, a key source of funding for research and development, who were affected by travel restrictions imposed due to COVID-19. The main sources of funding for higher education institutions are internal revenue, such as general university funds, direct funding from the Department of Education (e.g., block funding), and income from international students, which account for more than half of the total. Other significant sources of funding include government research funds (17% from general research funds and 15% from competitive funding provided by the ARC and NHMRC).

The major areas of research and development expenditure in higher education institutions are health sciences (29%), human society (14%), and information & computing sciences (12%), with the top 10 areas detailed as follows (Figure 1-17).

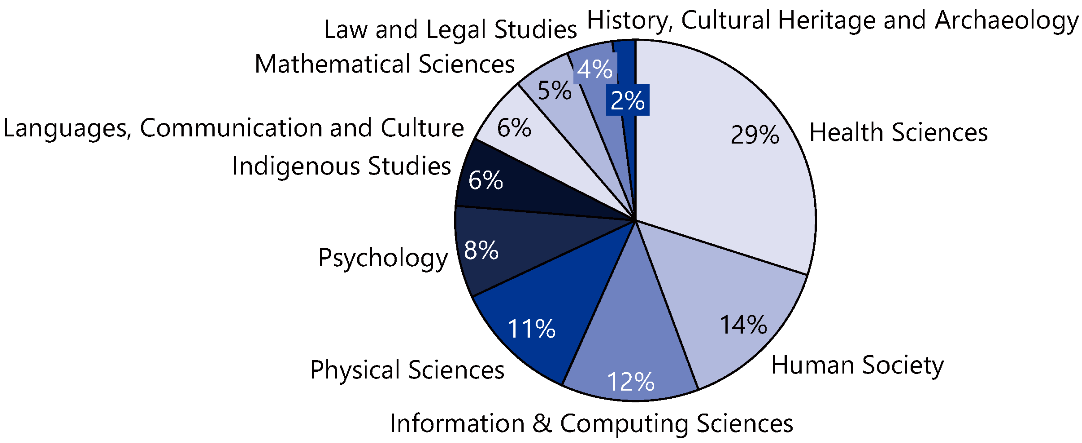


Figure 1-17 Top 10 Areas of R&D Expenditure in the Higher Education Sector (2019 Fiscal Year)

Source: Created by the author from Australian Bureau of Statistics' "Research and Experimental Development, Higher Education Organisations, Australia"

(3) Government Agencies' Research and Development Expenditure

In fiscal year 2020, research and development spending by Australian government agencies (GOVERD: Government expenditure on research and development) was approximately 3.6 billion AUD, an increase of 288 million AUD

10 Grassano, N. et al. (2022), "The 2022 EU Industrial R&D Investment Scoreboard", https://iri.jrc.ec.europa.eu/scoreboard/2022-eu-industrial-rd-investment-scoreboard

from the previous year. The percentage of GDP accounted for by this expenditure remained the same at 0.17%. The main reason for the increase in government research and development expenditure was an increase in block grants to universities, provided as temporary support to compensate for the decline in student fees income from international students, which supports university research.

The major areas of R&D expenditure amongst government agencies were agricultural, veterinary, and food sciences (19%), biomedical & clinical sciences (13%), and engineering (12%), with the top 10 areas detailed as follows (Figure 1-18).

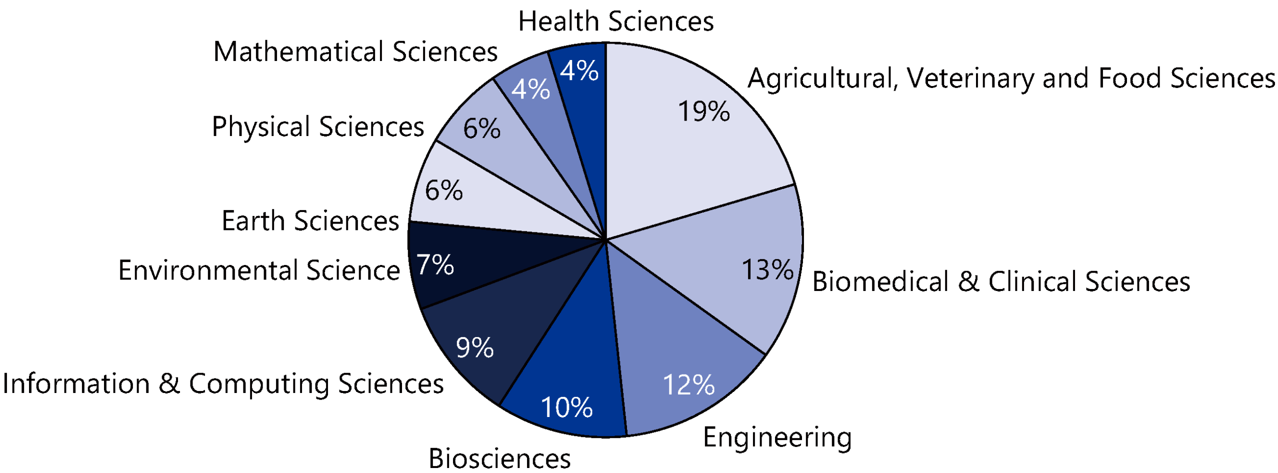


Figure 1-18 Top 10 Areas of R&D Expenditure in Government Agencies (2020 Fiscal Year)

Source: Created by the author from Australian Bureau of Statistics' "Research and Experimental Development, Government and Private Non-Profit Organisations, Australia"

(4) Non-Profit Organizations' Research and Development Expenditure

In fiscal year 2020, research and development spending by private non-profit institutions (PNPERD: Private non-profit expenditure on research and development) was approximately 1.4 billion AUD, an increase of 129 million AUD (about 10%) from the previous year. The expenditure as a percentage of GDP was 0.07%. While the research and development expenditure of private non-profit institutions accounts for about 4% of the total, 45% of this is spent on basic research.

The major areas of research and development expenditure amongst private non-profit institutions were biomedical & clinical sciences (76%), health sciences (10%), and biosciences (4%), with the top 10 areas detailed as follows (Figure 1-19).

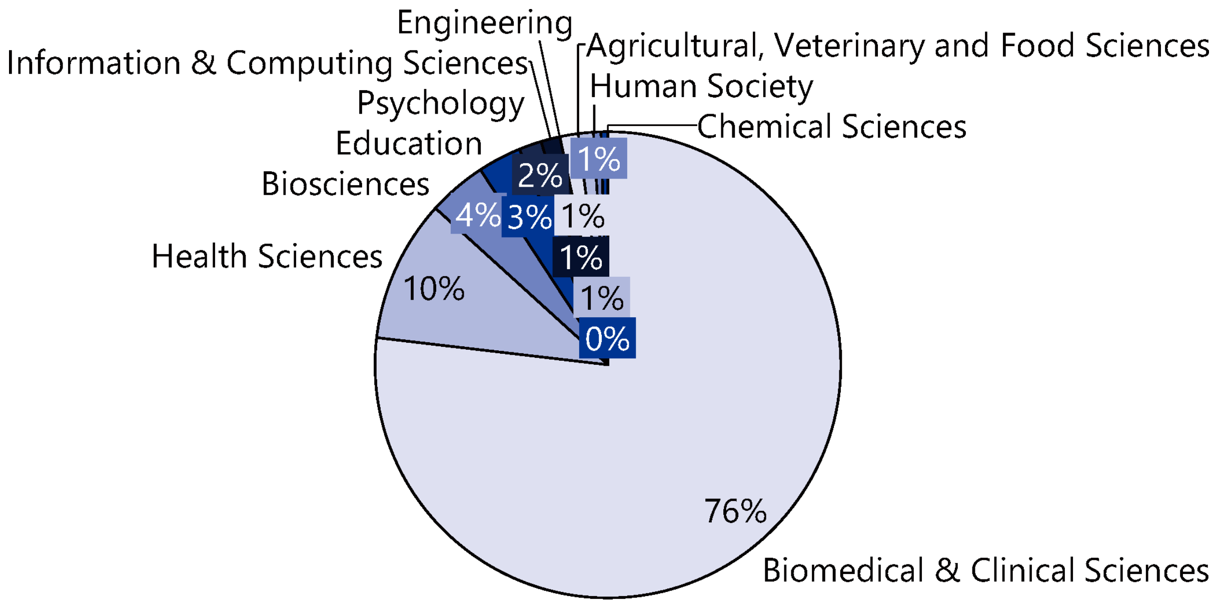


Figure 1-19 Top 10 Areas of R&D Expenditure in Private Non-Profit Institutions (2020 Fiscal Year)

Source: Same as Figure 1-18

1.2.3 Researchers

- Number of Researchers by Organization

About 180,000 individuals are involved in research in Australia, with about two-thirds being researchers. Focusing on the affiliation of researchers, the majority, about 70,000, are affiliated with higher education institutions. It is important to note that among the researchers affiliated with higher education institutions, there are those who actively engage in joint research with industry and those who participate in government-funded projects, indicating the presence of researchers active across multiple sectors. Next, about 35,000 researchers are affiliated with private institutions. Researchers in private institutions are employed in various industries such as healthcare, technology, and mining (Figure 1-20).

Private institutions contribute more than half of research and development expenditure, but in terms of the number of researchers, they account for about 30% of the total. Government agencies include the Commonwealth Scientific and Industrial Research Organisation (CSIRO)—a public research institution that represents Australia—The Australian Institute of Marine Science (AIMS), and the Australian Nuclear Science and Technology Organisation (ANSTO). Furthermore, private non-profit institutions include research institutions operated by charitable organizations and foundations. Details about the main research institutions and researchers will be introduced in the following sections.

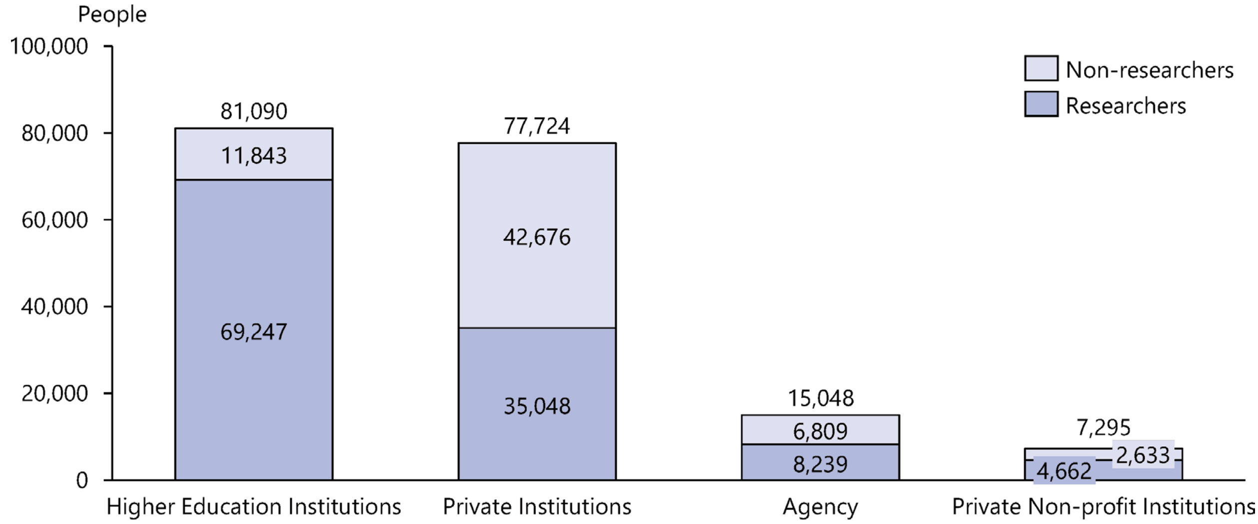


Figure 1-20 Number of Researchers by Organization (2021)

Source: Same as Figure 1-17

1.3 Information on STI Outputs

This section examines science and technology-related outputs in Australia. It organizes information on the number and quality of published papers, their breakdown by field, and the number of international co-authored papers, among other details. It also examines patent applications to understand the actual state of research in Australia and identify fields in which it has strengths.

1.3.1 Papers

(1) Number of Published Papers (by Fiscal Year)

The number of papers published by Australia has been steadily increasing year by year, from 83,267 in 2012 to 122,727 in 2021, with an annual growth rate of 4.4% from 2012 to 2021[11].

According to Japan's Ministry of Education, Culture, Sports, Science and Technology's Science and Technology Indicators 2022, based on a whole number basis, the number of papers Australia has published has more than doubled compared to ten years ago, and has increased 3.5 times compared to twenty years ago. Furthermore, its worldwide share of papers gradually increased, accounting for 3.9% in the 2018-2020 average. Additionally, 17% of all papers are within the top 10% of papers, with a share of 6.5% for the top 10% of papers, significantly exceeding the share of all paper numbers. Focusing on the top 1% of papers, 2.3% of all papers were within the top 1%, with a share of 9.2% for top 1% papers, significantly exceeding both the share of all papers and the share of top 10% papers. To more accurately assess the country's contribution to papers, calculating the number of papers using a fractional count reveals that although the growth rate and share of papers are lower than those of a whole number count, a similar trend is seen in the increase in the number of papers compared to the past, as well as in the rise in share. The fact that the share of top

11 Scimago Journal & Country Rank, "Australia," accessed March 28, 2023. https://www.scimagojr.com/countrysearch.php?country=AU

10% papers exceeds the share of all paper numbers is similar to that of the whole number count. Also, the fact that the share of top 1% papers exceeds both the share of all papers, and the share of top 10% papers shows a similar trend to that of a whole number count. Checking through an author count also confirms a similar trend to that of the whole number count and a fractional count. These results confirm that Australia's research presence has increased in both the number and quality of papers.

It is difficult to succinctly state the reasons for the increase in high-quality research outputs in Australia, but government support for research, the promotion of international joint research, and the strengthening of public-private partnerships are considered to be reasons. In recent years, the Australian government has been actively investing in research and development. For example, in December 2015, the National Innovation and Science Agenda (NISA) announced that more than 1 billion AUD would be provided for research and development. This support has resulted in high-quality research being conducted in various related fields. Additionally, in recent years, collaboration among researchers and institutions has become more active, contributing to the achievement of high-quality research outputs. The background of this collaboration includes international partnerships, cross-disciplinary research teams, and industry-academia collaboration. Details on government programs and international collaborations will be introduced in the following sections.

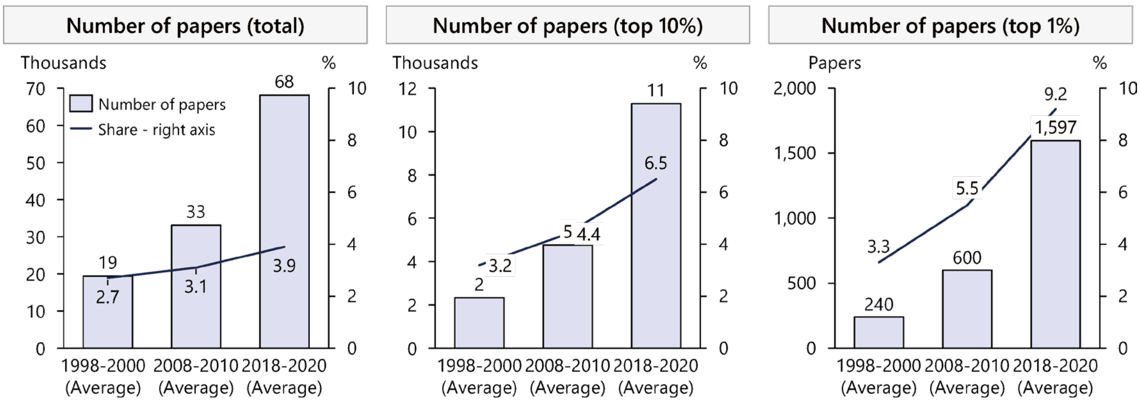


Figure 1-21 Number of Papers (Whole Number Count)

Source: Created by the author from Ministry of Education, Culture, Sports, Science and Technology's National Institute of Science and Technology Policy "Science and Technology Indicators 2022, Survey Material-318 (August 2022)"

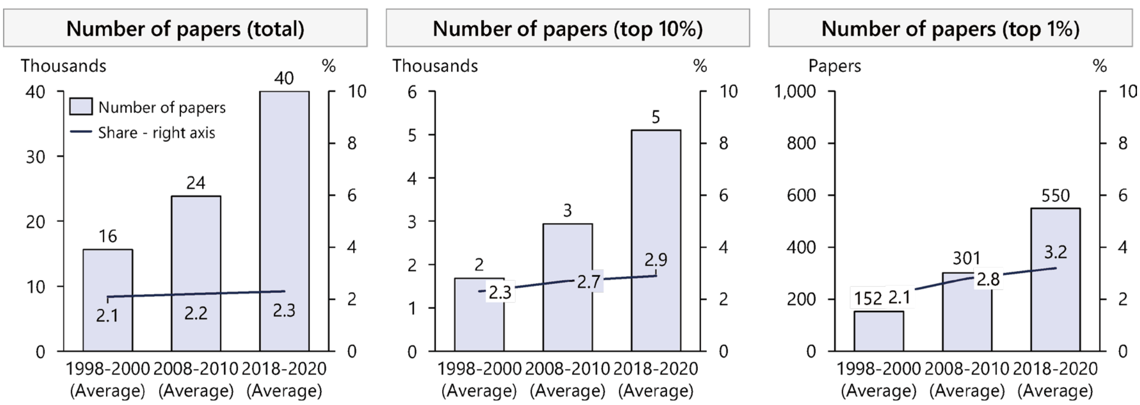


Figure 1-22 Number of Papers (Fractional Count)

Source: Same as Figure 1-21

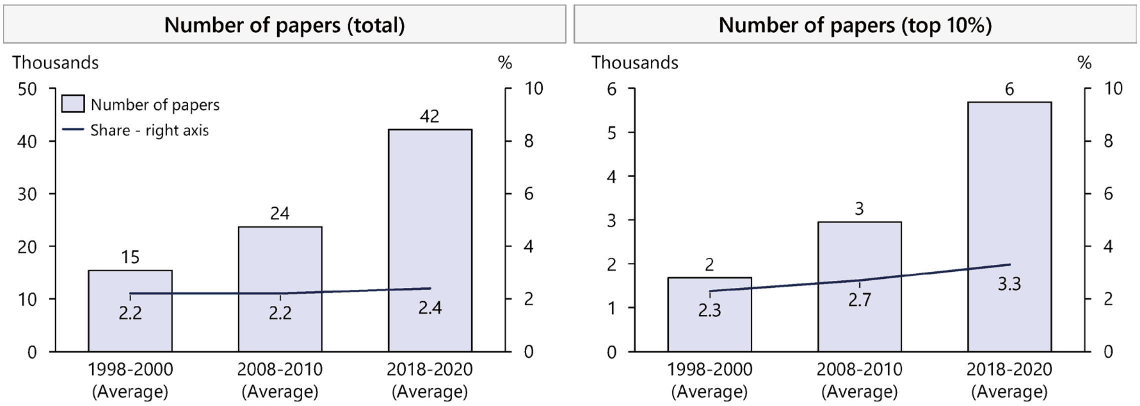


Figure 1-23 Number of Papers (Author Count)

Source: Same as Figure 1-21

(2) Number of Published Papers (by Field)

In 2021, the field with the largest share of papers published in Australia was medicine (21.6%). This was followed by social sciences (8.1%) and engineering (7.3%), as well as biochemistry, genetics and molecular biology (Figure 1-24).

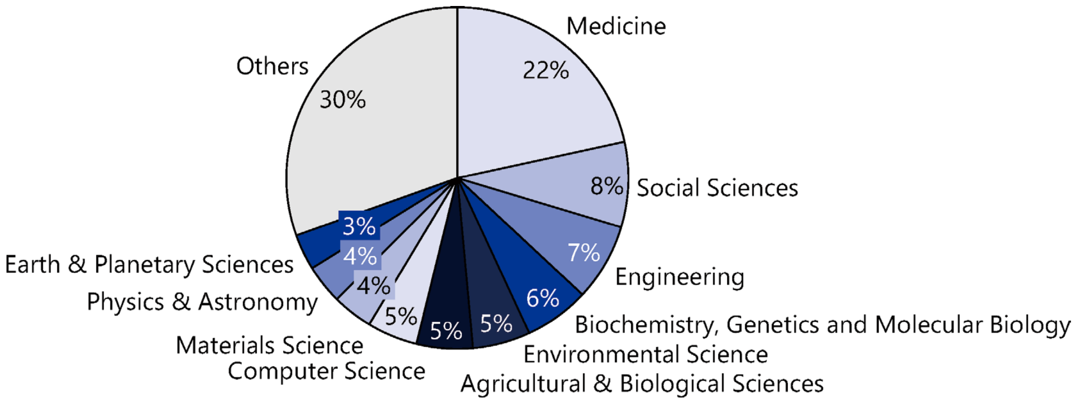


Figure 1-24 Share of Papers by Field (2021)

Source: Created by the Author from Scopus (ScimagoJR) "Scimago Journal & Country Rank – Australia"

Examining the average number of citations per paper, 5 out of the top 10 are related to medicine and biology, confirming Australia's strengths in these areas (Table 1-4). Additionally, the top cited papers are listed in Table 1-5.

Table 1-4 Fields with High Citation Counts

Field (Top 10 Average Citation Counts)	Average Citation Count (as of February 2023)	Medical & Biological Related
Immunology & Microbiology	40.21	✓
Biochemistry, Genetics & Molecular Biology	39.81	✓
Chemistry	33.07	
Neuroscience	32.35	✓
Chemical Engineering	29.99	
Earth & Planetary Sciences	29.60	
Agricultural & Biological Sciences	29.27	
Medicine	29.10	✓
Environmental Science	28.03	
Pharmacology, Toxicology & Pharmaceutics	27.84	✓

Source: Same as Figure 1-24

Table 1-5 Representative Papers of Australia (Most cited from 2016 to 2021)

Papers	Authors (Australia)	Affiliated Institutions	Citation Count
Cochrane handbook for systematic reviews of interventions	Matthew Page (Editor), Miranda Cumpston (Editor)	Monash University, University of Newcastle	21,924
Cancer statistics in China, 2015	Peter D. Baade, Xue Qin Yu	Cancer Council Queensland, University of Sydney, Cancer Council NSW	12,354
The third international consensus definitions for sepsis and septic shock (sepsis-3)	Rinaldo Bellomo	University of Melbourne	9,292
Observation of gravitational waves from a binary black hole merger.	N. S. Darman, P. D. Lasky, and others	University of Melbourne, Monash University, University of Adelaide	6,917
Analysis of protein-coding genetic variation in 60,706 humans	Monkol Lek, Eric V. Minikel, Kaitlin E. Samocha, Beryl B. Cummings & Aarno Palotie	University of Sydney, Children's Hospital at Westmead	5,954

Source: Created by the author from Elsevier's "Australia in the global research landscape and Elsevier in Australia (March 2022)"

(3) Proportion of Co-authorship

From 2016 to 2021, 56% of academic papers published in Australia were co-authored with international collaborators.

This is significantly higher than the average international collaboration rate of 21%. Located in the Asia-Pacific, Australia serves as a strategic location for research cooperation with neighboring countries such as China, Japan, and Korea. Furthermore, the Australian government has made substantial investments in research and development, encouraging international collaborations through funding assistance programs and initiatives. Additionally, the government provides mobility programs that enable Australian researchers to travel abroad for joint research with international partners or to host them in Australia. For example, the Endeavour Leadership Program has offered opportunities for outstanding international researchers to conduct research projects in Australia. Support is also provided to facilitate the entry of international researchers into Australia, such as expediting visa procedures and streamlining entry processes.

According to Elsevier, between 2016 and 2021, there were 21,798 Australian publications with corporate co-authors, accounting for 3.2% of all Australian publications. This exceeds the global percentage of 2.7%. 90% of Australian academic papers co-authored with corporations involve global companies, with medical and life sciences being the largest cooperative fields[12]. The top three countries for research collaboration with Australia are the United States, China, and the United Kingdom, with Japan ranking sixth (Figure 1-25). However, it is important to note that these numbers and rankings may vary depending on the data source. Australia's international relations in science and technology are discussed in Chapter 5.

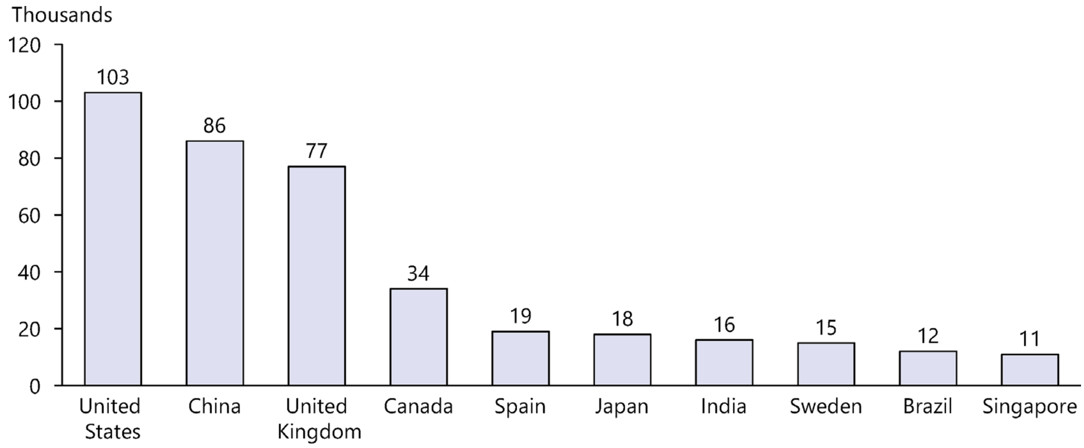


Figure 1-25 Top 10 International Research Collaborators with Australia (2016-2021)

Source: Same as Table 1-5

1.3.2 Patents

- Patent Applications (By Year and Field)

According to IP Australia (the Australian intellectual property agency), the number of patent applications in Australia is expected to have grown by 10% in 2021 to 32,937, compared to the previous year. However, examining the long-

12 Elsevier "Australia in the global research landscape and Elsevier in Australia (March 2022)", https://www.elsevier.com/__data/assets/pdf_file/0008/1279286/20220407-Australia-Report.pdf

term trends, there has been some fluctuation but no significant change (Figure 1-26). The top 5 fields of patent technology are pharmaceuticals, medical technology, biotechnology, organic fine chemistry, and computer technology, accounting for about 70% of the total number of patent applications in 2021.

Active patent applications are seen from both domestic and foreign entities, with the top 5 domestic applicants in 2021 being Aristocrat Technologies Australia (a gaming company), the CSIRO (a public research institution), NewSouth Innovation (a technology transfer company affiliated with the University of New South Wales), ResMed (a medical device manufacturer), and Breville (an appliance manufacturer). The top 5 foreign applicants are, as shown in Figure 1-27, LG Electronics (a South Korean conglomerate), Huawei Technologies (a Chinese communications equipment manufacturer), Guangdong Oppo Mobile Telecommunications (a Chinese communications equipment manufacturer), Nestle (a Swiss food manufacturer), and Apple (an American electronics manufacturer)[13].

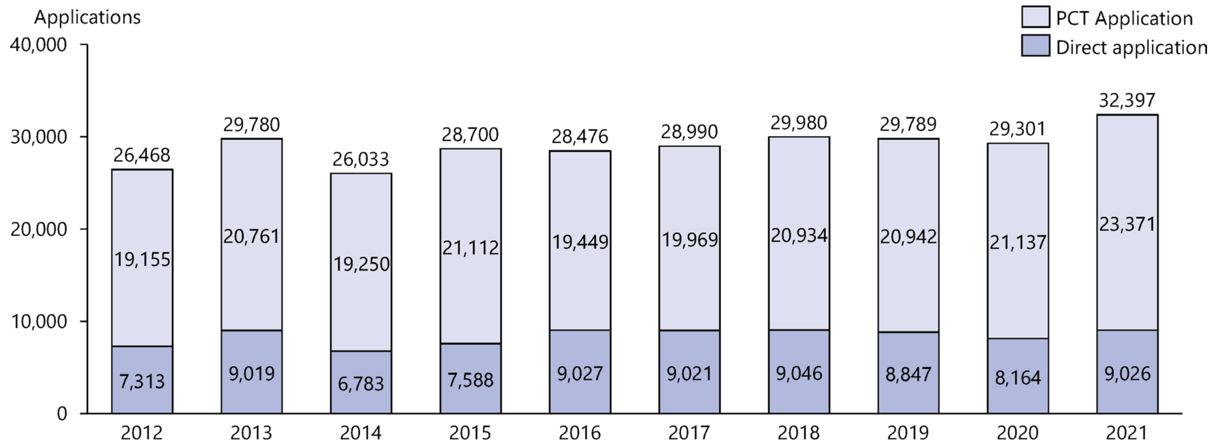


Figure 1-26 Patent Application Trends

Source: Created by the author from IP Australia's "Australian Intellectual Property Report 2022"

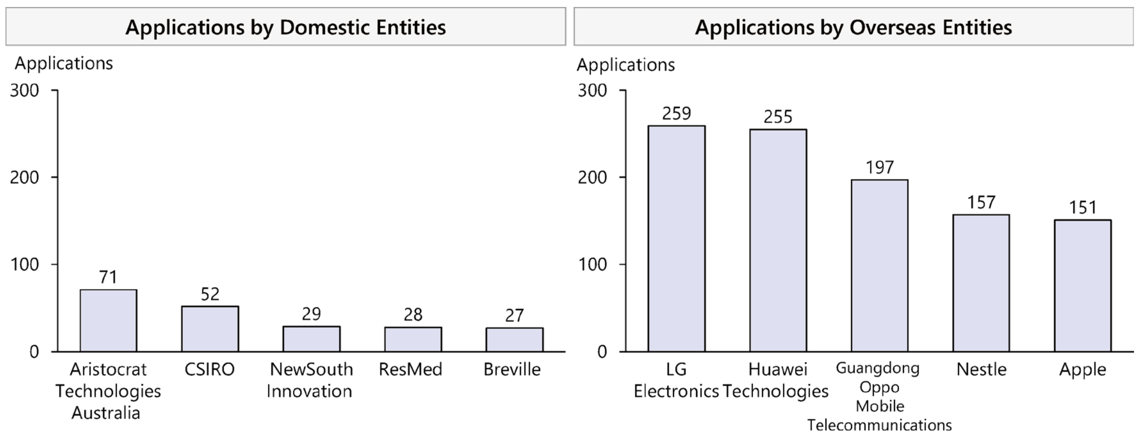


Figure 1-27 Number of Patent Applications by Domestic and Foreign Entities (2021)

Source: Same as Figure 1-26

13 IP Australia "Australian Intellectual Property Report 2022", https://www.ipaustralia.gov.au/tools-and-research/professional-resources/data-research-and-reports/~/-/media/Project/DXA/IPAustralia/PDF/australian-intellectual-property-report-2022.pdf

1.4 Information on STI Outcomes

This section outlines Australia's innovation capacity and international competitiveness, as well as the efforts and achievements of Australian STI research and development. The first part touches on Australia's ranking in the Global Innovation Index 2022 and international STI-related indicators and awards. The latter part organizes information on technology-intensive companies, emerging businesses, and unicorns, comparing Australia's major and promising new players with those from other countries.

1.4.1 National Competitiveness

- International Competitiveness (Global Innovation Index 2022)

The Global Innovation Index (GII) aims to capture the multifaceted aspects of innovation through approximately 80 indicators classified into innovation inputs (human capital, private investment, government support, scientific and technological foundations, etc.) and outputs (patents, technological innovation, creativity, social impact, etc.). The results reveal the competitive strength of countries based on their capacity to innovate. In the 2022 GII, Australia ranked 25th, compared to Japan's 13th place (Table 1-6). Australia is ranked 25th out of 48 high-income countries and 7th out of 17 countries in Southeast Asia, East Asia, and Oceania, which, compared to the country's wealth and output of academic papers, is not a high level. Focusing on innovation input and output, Australia's input rank was 19th, and its output rank was 32nd in 2022, indicating a lower ranking in output. In other words, although resources are available, their potential is not being fully utilized, meaning results do not match. The Australian government is keenly aware that research outcomes are not sufficiently contributing to industry and commerce, which is considered to be behind the shift in emphasis from basic to applied research and the promotion of active industry-government-academia collaboration.

Table 1-6 Australia's GII Ranking

Year	Overall (GII) Rank	Input Rank	Output Rank
2020	23rd	13th	31st
2021	25th	15th	33rd
2022	25th	19th	32nd

Source: Created by the author from the World Intellectual Property Organization's "Global Innovation Index 2022 - Australia"

1.4.2 Research and Education Competitiveness

(1) Science and Technology Awards (Nobel Prizes, etc.)

The Nobel Prize is recognized as one of the highest awards for outstanding achievements in fields such as physics, chemistry, physiology or medicine, literature, economics, and the promotion of peace. Since 1901, there have been 15 Australian recipients (including naturalized citizens). Eight recipients were from the fields of physiology or medicine (Table 1-7).

Table 1-7 List of Australian Nobel Laureates

Year	Field	Laureate	Reason for Award
2011	Physics Prize	Brian Schmidt	Research on the accelerating expansion of the universe (astrophysics)
2009	Physiology or Medicine Prize	Elizabeth Blackburn	Discovery of telomeres and telomerase enzyme, the key to lifespan
2005	Physiology or Medicine Prize	Barry Marshall	Discovery of Helicobacter pylori's role in gastric ulcers
		Robin Warren	
2003	Literature Prize	John Coetzee	Depiction of the involvement of an outsider in innumerable guises
1996	Physiology or Medicine Prize	Peter Doherty	Research on the specificity of the cell mediated immune defence
1975	Chemistry Prize	John Cornforth	Study on the stereochemistry of enzyme-catalyzed reactions
1973	Literature Prize	Patrick White	Epic narratives of Australian life
1970	Physiology or Medicine Prize	Bernard Katz	Discoveries concerning the humoral transmitters in the nerve terminals and the mechanism for their storage, release, and inactivation
1964	Physics Prize	Aleksandr Prokhorov	Fundamental work in the field of quantum electronics, which has led to the construction of oscillators and amplifiers based on the maser-laser principle
1963	Physiology or Medicine Prize	John Eccles	Discoveries concerning the ionic mechanisms involved in excitation and inhibition in the peripheral and central portions of the nerve cell membrane
1960	Physiology or Medicine Prize	Frank Macfarlane Burnet	Research on "tolerance" and its importance in organ transplantation
1945	Physiology or Medicine Prize	Howard Florey	Discovery of penicillin and its curative effect in various infectious diseases
1915	Physics Prize	William Bragg	Analysis of crystal structures by means of X-rays
		Lawrence Bragg	

Source: Created by the author from the Nobel Prize Foundation's "Nobel Prize facts" and Australian Geographic, "Australia's Nobel Prize winners (August 4, 2015)"

(2) University Rankings

Australia has 43 universities, of which 36 were ranked in the top 1000 worldwide universities by Times Higher Education in 2022. While Australia has fewer higher education institutions compared to Japan, each university is expected to maintain high quality in research and education. Universities are committed to continuous self-evaluation and improvement to maintain and enhance quality. As a result, the majority of Australian universities possess high levels of education and research. Among them, the Group of Eight (Go8) is recognized as a leading research university group, with its 8 member universities ranked at the top (Table 1-8).

Table 1-8 Rankings of Australian Universities (Top 8)

University Name	THE 2023 Rank	Strengths (STI-related)
University of Melbourne	34	· Biomedical and Health Sciences · Sustainability and Environment · Computing and Information Systems
Monash University	44	· Biomedical and Health Sciences · Sustainable Development · Materials Science & Engineering · Data Science and Artificial Intelligence
University of Queensland	53	· Biomedical and Health Sciences · Sustainable Development · Engineering and Technology · Quantum Science and Technology
University of Sydney	54	· Biomedical and Health Sciences · Sustainability and Environment · Data Science and Artificial Intelligence
Australian National University	62	· Biomedical and Health Sciences · Astronomy & Astrophysics · Sustainability and Environment
University of New South Wales	71	· Engineering and Technology · Biomedical and Health Sciences · Sustainable Development · Data Science and Artificial Intelligence
University of Adelaide	88	· Agriculture & Food · Biomedical and Health Sciences · Energy & Resources · Sustainability and Environment
University of Western Australia	131	· Biomedical and Health Sciences · Agriculture & Environment · Engineering & Energy · Data Science and Artificial Intelligence

Source: Created by the author from Times Higher Education, "THE World University 2022-2023 ranking"

1.4.3 Competitiveness in Business and Industry

Examining industry, new technologies are emerging, and technology-intensive companies, startups, and unicorn companies are being created, backed by private investment in research and development and the high research and development capabilities of universities and other institutions.

(1) Number of Technology-intensive Companies

According to the data as a service company, BoldData, there are over 33,000 technology companies scattered across major cities in Australia. Sydney alone has more than 10,000 technology companies, accounting for a third of the total. Melbourne follows with 9,061 companies (28% share), then Brisbane with 5,848 companies. Together, these three cities account for about 80% of all technology companies in Australia[14].

According to The Australian Securities Exchange (ASX), there are currently 186 companies listed in the information technology sector, divided into the following three industry groups:

1. Software and Services: Companies providing consulting, data processing, internet services, applications, and system software
2. Technology Hardware and Equipment: Companies manufacturing and selling electronic equipment and instruments, technology hardware, storage, peripherals, and communication equipment
3. Semiconductors and Semiconductor Equipment: Technology companies manufacturing and supplying semiconductors and semiconductor equipment

The main technology companies listed on the ASX are as follows (Table 1-9).

Table 1-9 Technology Companies Listed on the Australian Securities Exchange[15] (Top by Market Capitalization)

Company Name	Company Value (Billion AUD)	Industry Classification
WiseTech Global Limited	19.8	Software and Services
Xero Limited	11.5	Software and Services
Altium Limited	5.1	Software and Services
Technology One Limited	4.7	Software and Services
NEXTDC Limited	4.5	Software and Services
Block Inc.	3.6	Software and Services
Dicker Data Limited	1.9	Technology Hardware and Equipment
Iress Limited	1.8	Software and Services

Source: Created by the author from the Australian Securities Exchange "Company Directory (as of February 17, 2023)"

(2) Number of Startup Companies

Australia has a vibrant startup ecosystem, producing 10 unicorns (startups valued at over 1 billion US dollars) and 19 soonicorns (companies expected to reach unicorn status) to date. There are also companies valued at over 1 billion US dollars that did not reach this valuation during their non-listed period. Examples include Afterpay, REA Group, SEEK, Carsales.com, Domain, Zip, SiteMinder, etc.

The most promising unicorn companies are as follows (Table 1-10).

14 BoldData, "List of Technology Companies Australia," accessed January 31, 2023. https://bolddata.nl/en/companies/australia/technology-companies-australia/

15 Companies classified under "Software and Services" or "Technology Hardware and Equipment" in the industry classification of the Australian Securities Exchange

Table 1-10 Main Unicorn Companies in Australia

Company Name	Expected Company Value (Billion USD)	Business Overview
Canva:	40	Provides free online graphic design tools
Airwallex	5.5	Provides financial technology platforms for companies growing across borders
Immutable	2.5	Provides platforms for Web3 game developers
SafetyCulture	1.6	Provides platforms for inspections, issue identification, and corrective actions in daily operations
Culture Amp	1.5	Provides digital platforms to enhance employee engagement
Linktree	1.3	Provides platforms for individuals and companies to effectively and efficiently disseminate information on social media
GO1	1	Provides e-learning platforms
Pet Circle	1	An online pet shop
Scalapay	1	Provides payment services using fintech
Atlassian	(Listed)	Develops products for software developers, teams, and project managers
Judo Bank	(Listed)	Provides lending services for small and medium-sized enterprises

Source: Created by the author from Felix Harvey's "Australianunicorns.com (as of February 17, 2023)"

2 STI Organizations and Systems

2.1 Overview of Organizations and Systems

This section introduces the main stakeholders related to STI in Australia and outlines their roles and functions. It also organizes the direction of STI, the decision-making process, and how funding from the government reaches research organizations.

In Australia, the Prime Minister sets the direction for the country's STI through initiatives such as the National Innovation and Science Agenda (NISA), with relevant agencies and departments building their strategies and policies in their respective areas of jurisdiction. These departments collaborate with funding agencies, regulatory bodies, and policy-making institutions to implement policies. The direction set by the Prime Minister is just that - a direction. Main departments related to STI, such as the Department of Industry, Science and Resources (DISR), Department of Education (DoE), and Department of Defence (DoD), each build their own strategies. These strategies are not coordinated or integrated across departments, leading to variations in areas of focus and policy content. Thus, it is important to note that Australia's STI policy does not have a unified strategy based on government policy or coordinated policies and actions among departments based upon that style of government policy.

The first part of this section introduces the main related departments and touches on funding agencies, public research institutions, and major universities. The latter part introduces prominent researchers in STI-related fields and the research institutions they belong to. It also introduces trends in international collaboration and Australia's research platforms and bases.

2.1.1 Organizational Chart of Australia's Science and Technology Administration

The institutions related to STI can be broadly classified into three categories. The first is institutions that determine the direction and policy of STI, the second is institutions that provide research grants to move policies forward (funding agencies), and the third is institutions that conduct actual research. However, as mentioned earlier, there are hierarchies in policymaking, including national policies, department-level policies, and policies at the level of affiliated institutions. As well as departments deeply involved in STI such as the DISR and DoE, departments like the Department of Agriculture, Fisheries and Forestry (DAFF) and the Department of Health and Aged Care (DHAC) have their own STI strategies, funding agencies, and research institutions, making the overall picture of STI-related institutions complex.

To illustrate the hierarchy and relationships of STI-related institutions, an organizational chart of STI institutions including key stakeholders has been created (Figure 2-1). Note that in Australia, organizational changes and name changes are commonplace. Therefore, the chart is current as of January 2023.

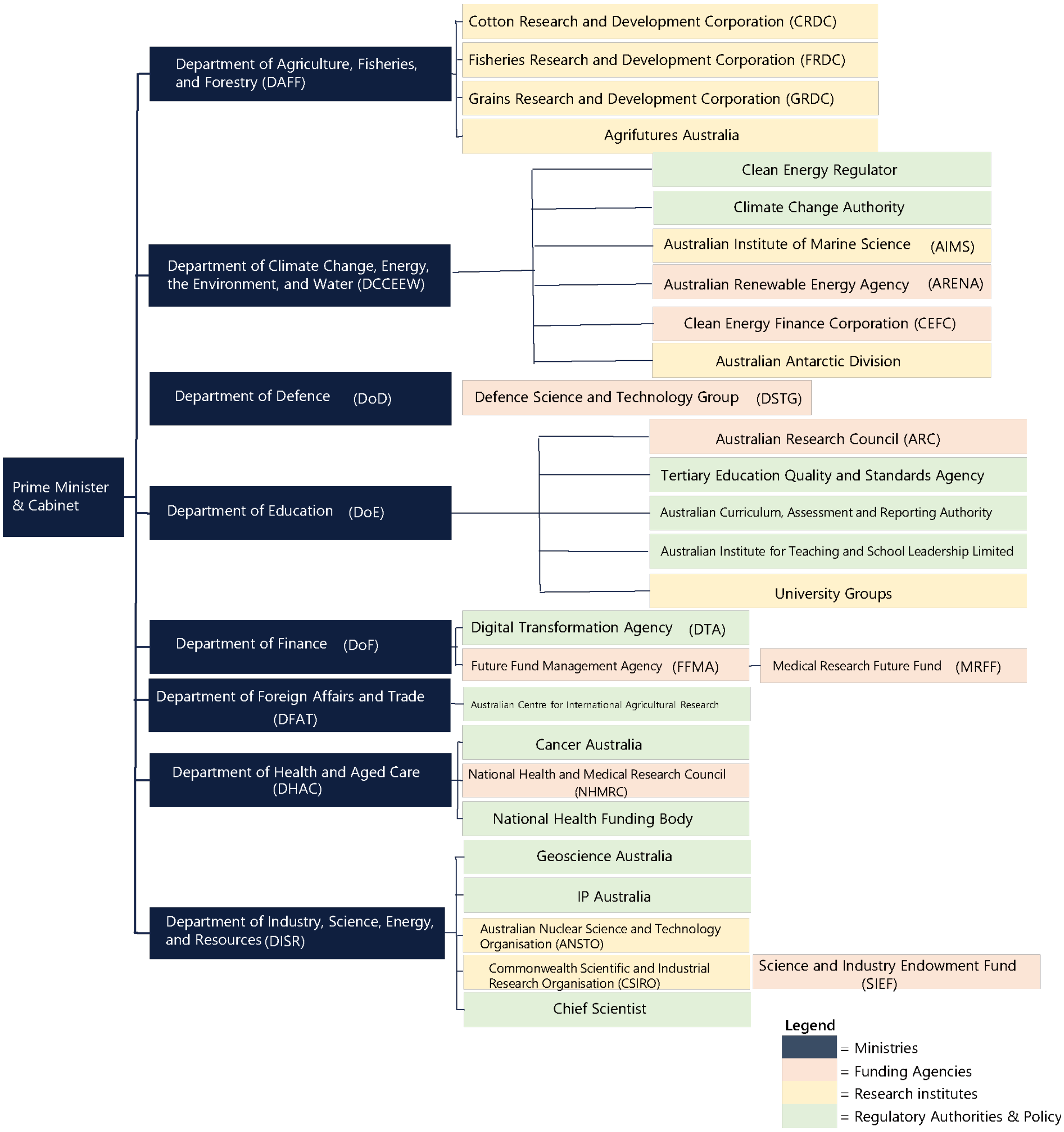


Figure 2-1 Organizational Chart of STI-related Institutions

Source: Created by the author based on public information and interviews

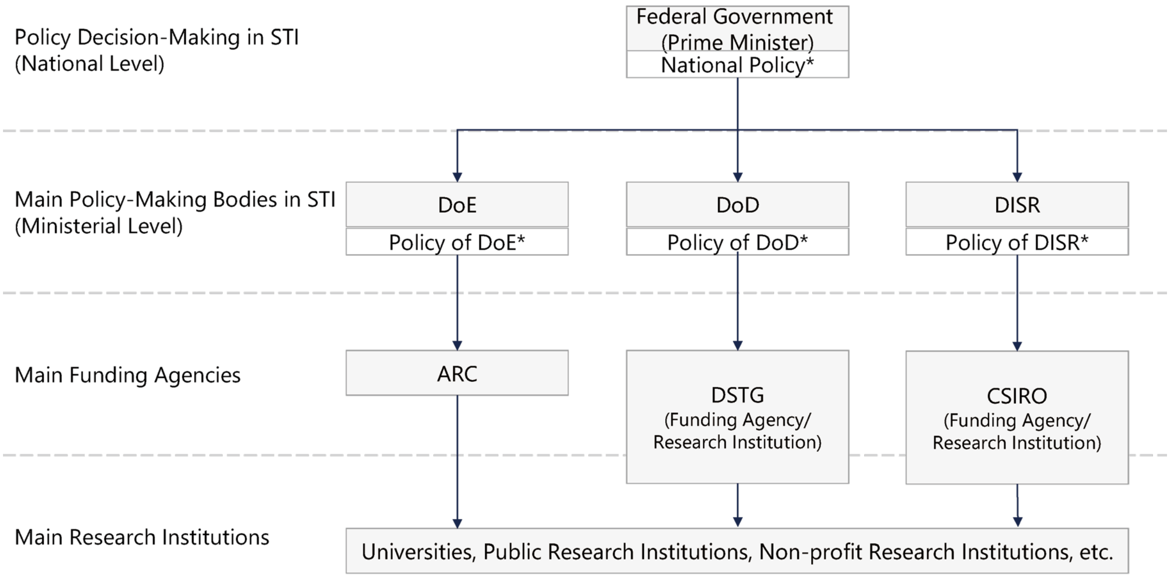
As mentioned earlier, examining research and development expenses in monetary terms, 80% is spent on applied research and experimental development research. Focusing on basic research, the main policy-making institutions, funding agencies, and research institutions are as follows.

Table 2-1 Main STI-Related Institutions for Basic Research

Direction & Policy-Making Institutions	Funding Agencies	Research institutes
· Department of Education (DoE) · Department of Industry, Science, and Resources (DISR) · Department of Defence (DoD)	· Australian Research Council (ARC) · National Health and Medical Research Council (NHMRC) · Defence Science and Technology Group (DSTG)	· Domestic Universities · Commonwealth Scientific and Industrial Research Organisation (CSIRO) · Australian Nuclear Science and Technology Organisation (ANSTO)

Source: Created by the author based on public information, interviews, etc.

The flow of funds from policy decisions by these groups through to research is summarized as follows.



*Note: The policies of each ministry are made in line with national policies, However, due to the vertically divided structure, government coordination between ministries is limited.

Figure 2-2 Flow of Funds from Policy Decision to Research

Source: Created by the author based on public information, interviews, etc.

The primary entities conducting basic research are universities. The DoE oversees these universities, providing funding through block grants and similar means. The funding agency ARC, which provides competitive funding through its programs, is also beneath the DoE. Note that the ARC does not cover the medical field. Instead, competitive funding in the medical field is provided through NHMRC under the DHAC.

The DISR is a department responsible for industrial policy, having under it public research institutions representing the country such as the CSIRO and ANSTO. The CSIRO and ANSTO conduct research, including basic research, based on policies and strategies set by the DISR. In addition to research functions, they also have partial funding functions, supplying competitive funds and others to companies and universities.

The DoD develops STI policies and strategies specialized in defence. The DSTG, which is under the DoD's umbrella, is deeply involved in STI in particular, exercising funding and research functions within the ministry.

The research stage covers everything from basic research to experimental development research. Since it is related to national defense, information disclosure is limited, and details about funding targets, programs, institutions collaborating in research, and initiatives are often unclear.

The following sections introduce major institutions related to STI.

2.2 Relevant Ministries

This section focuses on the DISR, DoE, and DoD, which have high relevance to STI, to organize an overview of organizations and strategies and initiatives related to STI. It also introduces the current ministers in charge.

2.2.1 Department of Industry, Science, and Resources (DISR)

The DISR oversees the government's efforts to integrate industry, energy, resources, and science to promote economic growth, productivity, and competitiveness. Previously known as the Department of Industry, Innovation, and Science (DIIS), its name changed on February 1, 2020. Currently, Ed Husic, Minister for Industry and Science, and Madeleine King, Minister for Resources and Northern Australia, lead the department.

The DISR aims to build a strong science system by ensuring participation in science by all Australians, enhancing capabilities and skills, creating new research, knowledge, and technology, and improving Australia's societal, economic, health, and environmental outcomes through science. The DISR has several related institutions underneath it, including the CSIRO and ANSTO, representing public research institutions in Australia. It also has a function to directly provide funds to research institutions and organizations. The various funds contributed can influence the direction and approach of research initiatives. For example, in the field of basic research amongst public research institutions.

2.2.2 Department of Education (DoE)

The DoE's main role is formulating education and research policies, including budget allocation, curriculum development, managing teacher qualifications, and coordinating education policies with state governments. It directly supports research by providing block grants to the universities under it. The ARC, a leading domestic funding agency also located under the DoE, provides research grants primarily in the field of basic research. The ARC develops funding programs based on DoE's policies, offering competitive funding to support the realization of STI strategies. DoE also has individual research support initiatives, such as the University Research Commercialization Action Plan, investing 2.2 billion AUD to promote university innovation and collaboration with industry. However, this initiative primarily targets applied research and experimental development research, not basic research.

Currently, Jason Clare serves as the Minister for Education.

2.2.3 Department of Defence (DoD)

The DoD is an organization aimed at protecting Australia's national interests, promoting safety and stability, and supporting Australian society based on government directives. The Department of Defence oversees the Defence

Science and Technology Group (DSTG), an organization that manages STI in the defense and military sectors, and directly supervises it.

Currently, Richard Marles serves as the Deputy Prime Minister and Minister for Defence.

2.2.4 Other Relevant Ministries

Beyond the main STI-related ministries mentioned above, this section introduces STI initiatives within other ministries.

(1) Department of Agriculture, Fisheries and Forestry (DAFF)

The DAFF supervises and works to develop and strengthen Australia's agriculture, fisheries, and forestry industries. It also manages biosecurity risks to protect these industries. Currently, Murray Watt, Minister for Agriculture, Fisheries, and Forestry and Emergency Management, has set priorities including strengthening the national biosecurity system, promoting sustainable and environmentally friendly agriculture, fisheries, and forestry, and aiming to grow the agriculture, fisheries and forestry sector to 100 billion AUD by 2030.

Under the DAFF, there are organizations involved in STI with funding and research functions, such as the CRDC, FRDC, and GRDC to be mentioned later[16].

(2) Department of Climate Change, Energy, the Environment, and Water (DCCEEW)

The DCCEEW was established to address government challenges related to climate change and energy and to protect the environment and water resources. After several reorganizations and name changes, the ministry was launched in July 2022. Currently, Chris Bowen serves as the Minister for Climate Change and Energy, focusing on building an energy system responsive to climate change, protecting the environment, biodiversity, and heritage, managing water resources, and implementing policies and programs in Antarctica and the Southern Ocean.

STI-related institutions under the DCCEEW include research functions such as AIMS and funding functions such as CEFC[17].

(3) Department of Finance (DoF)

The DoF plays a critical role as a central agency in the Australian government, supporting a wide range of policy areas to achieve government outcomes. The DoF is involved in providing funding to the science and technology sector through budget allocation. It also oversees the Future Fund Management Agency (FFMA), which contributes funds to the Medical Research Future Fund (MRFF) for large research grants. Furthermore, it evaluates the use of resources in terms of the effectiveness of research and development investments, promotion of technological innovation, and improvement of industrial competitiveness. It is also involved in tax incentives for research and development and policy formulation.

Currently, Katy Gallagher serves as the Minister for Finance, Minister for the Public Service, and Minister for

16 DAFF, "Corporate Plan 2022-2023", https://www.agriculture.gov.au/sites/default/files/documents/daff-corporate-plan-2022-23.pdf

17 DCCEEW, "Corporate Plan 2022-2023", https://www.dcceew.gov.au/sites/default/files/documents/corporate-plan-2022-23.pdf

Women[18].

(4) Department of Foreign Affairs and Trade (DFAT)

DFAT promotes and protects Australia's international interests to support the country's safety and prosperity. It cooperates with international partners and other countries to address global challenges, stabilize the region, increase trade and investment opportunities, and contribute to Australian society. From an STI perspective, provides contributions through international cooperation in science and technology, including researcher exchanges, promoting international innovation through collaboration with overseas companies, and protecting international intellectual property.

Currently, Penny Wong serves as the Minister for Foreign Affairs, managing Australia's international presence through over 120 embassies, high commissions, consulates-general, and liaison offices across five continents[19].

(5) Department of Health and Aged Care (DHAC)

The DHAC works to ensure all Australians can be healthier, developing and implementing policies and programs on health, aged care, and sports, and advising the Australian government, based on cooperation with various stakeholders. From an STI perspective, it houses the National Health and Medical Research Council (NHMRC), which provides competitive funding in medical fields not covered by the ARC. Compared to the ARC, NHMRC invests a smaller proportion in basic research but is a leading funding agency in the medical field. It also manages the large Medical Research Future Fund (MRFF), which provides research funding for applied research and experimental development.

Currently, Mark Butler serves as the Minister for Health and Aged Care[20].

2.3 Funding Agencies

Australia has various research funding agencies, with the main ones for basic research being the Australian Research Council (ARC), the National Health and Medical Research Council (NHMRC), and the Defence Science and Technology Group (DSTG). As mentioned, the ARC covers areas excluding the medical field, while NHMRC specializes in it. Approximately 80% of the ARC's funding and about 40% of NHMRC's funding target basic research. However, there is a government direction to shift focus from basic to applied research, a direction expected to continue under the new administration. The DSTG, a funding agency under the DoD, focuses its research on defense-specific topics, regardless of the research stage.

Other agencies, large and small, focus mainly on promoting commercialization through applied research and experimental development research.

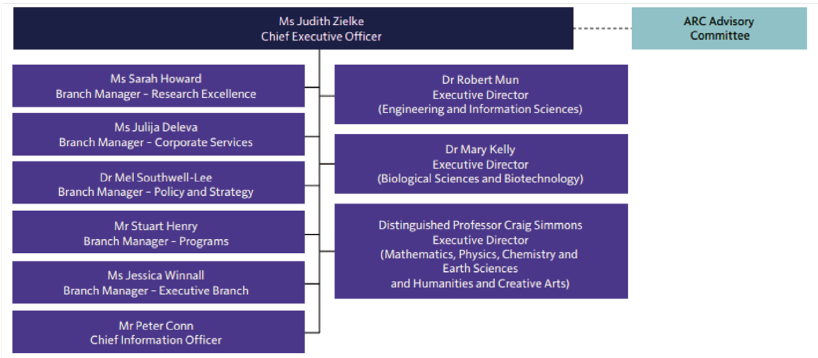
18 DoF, "Corporate Plan 2022-2023", https://www.finance.gov.au/publications/corporate-plan/corporate-plan-2022-23

19 DFAT, "About us", accessed January 20, 2023. https://www.dfat.gov.au/about-us

20 DHAC, "About us", accessed January 20, 2023. https://www.health.gov.au/about-us

2.3.1 Australian Research Council (ARC)

The ARC, an agency under the DoE, was established based on the Australian Research Council Act of 2001. It manages The National Competitive Grants Program (NCGP), providing approximately 800 million AUD annually to robust research projects. Its grants target all fields except clinical and other medical research, supporting research from basic to applied. The ARC also advises the government on research. The following is an overview of the ARC's budget, staff numbers, organizational chart, and top management.

<table>
<tr><td>Budget</td><td>AUD 832.1 million (FY 2021-2022)
※Total resourcing and payments (Payments made)</td></tr>
<tr><td>Staff</td><td>136 (FY 2021-2022)</td></tr>
<tr><td>Organizational Chart
(As of June 2022)</td><td>


</td></tr>
<tr><td>Top Management
(CEO) Introduction</td><td>■ Chief Executive Officer (CEO): Judi Zielke PSM (Public Service Medal recipient) Ms. Zielke was appointed CEO of ARC on February 1, 2022. Before joining ARC as CEO, she served as the Chief Operating Officer (COO) of the CSIRO, overseeing the organization's operations, particularly in governance, corporate activities, finance, infrastructure, and major investments.</td></tr>
</table>

Figure 2-3 Overview of the ARC's Organization

Source: Created by the author from ARC's "Annual Report 2021-22" and Ms Judi Zielke PSM

The ARC's research funding is broadly categorized into two areas based on the stage of research. One focuses on basic research (blue-sky) through the Discovery Program, and the other on commercialization through the Linkage Program[21]. In 2022, Discovery Program grants represented 78% of the ARC's total grants. Project numbers were of a similar ratio (Figure 2-4).

21 ARC, "National Competitive Grants Program", accessed January 31, 2023. https://www.arc.gov.au/funding-research

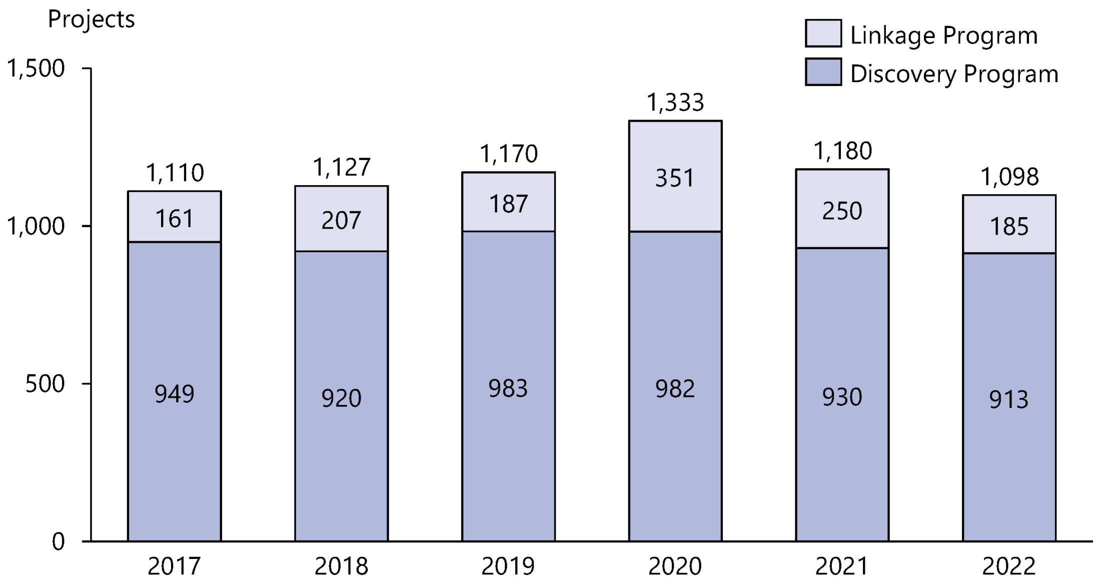


Figure 2-4 ARC Project Number Trends

Source: Created by the author from ARC's "Trend Visualisation"

About 80% of ARC-funded projects are international collaborations (Figure 2-5). As mentioned earlier, while the average international co-authorship rate in papers is about 20%, Australia's average exceeds this significantly at over 50%. The fact that ARC-funded projects have an even higher rate of 80% suggests that Australia is actively engaged in international collaborative research and that ARC places a high value on such collaborations.

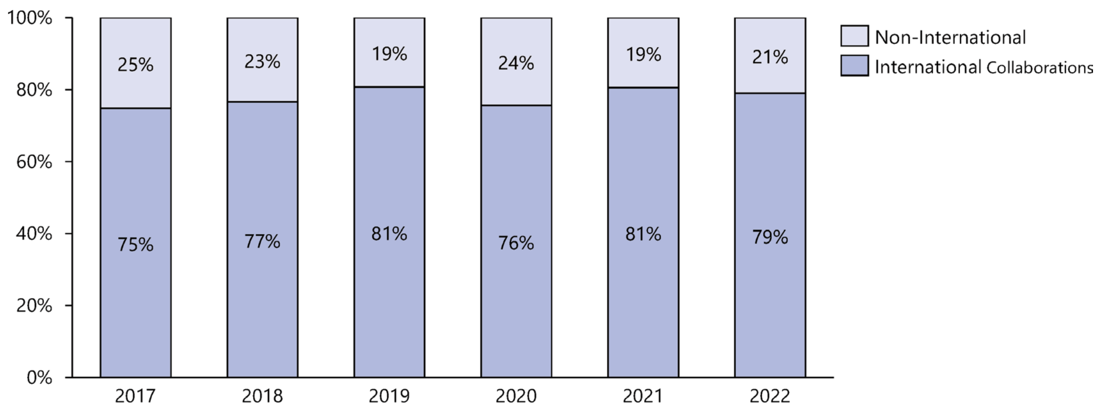


Figure 2-5 Proportion of International Collaborations in ARC-Funded Projects

Source: Same as Figure 2-4

The top five partner countries amongst ARC-funded international collaborations are the United States, the United Kingdom, Germany, Canada, and China. Including Japan among these five, the top three countries (USA, UK, Germany) account for three-quarters of ARC's international collaborations. However, China's share has been decreasing annually from 12% in 2019 to 7% in 2022 (Figure 2-6). In the co-authorship rate mentioned later, the United States and China are Australia's two major co-authoring countries, with nearly equal shares. Compared to this, China's rate is lower for ARC-funded projects, and its gap with the United States is significant. An interview with a former senior ARC staff member indicated that the choice of collaboration country does not affect project selection rates.

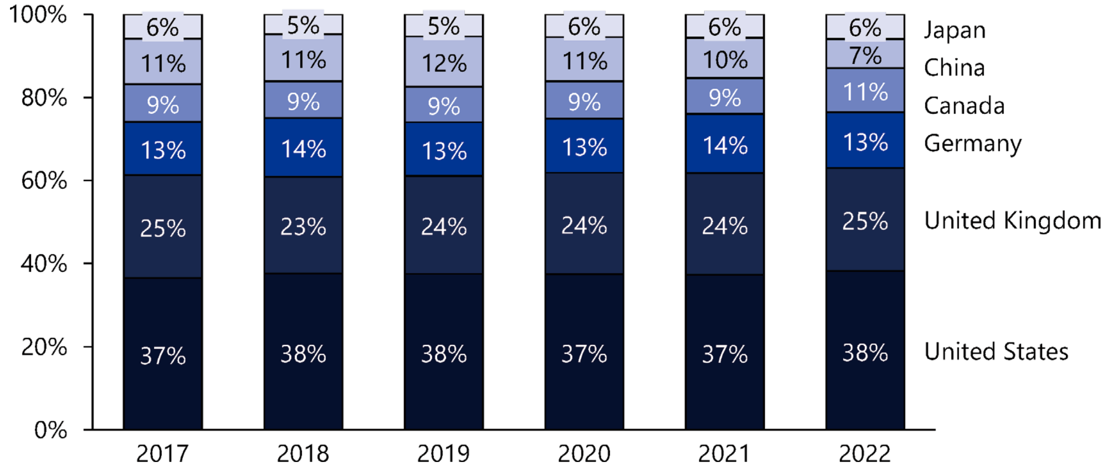


Figure 2-6 Share of Partner Countries in ARC-Funded Projects (Top 5 Countries and Japan)

Source: Same as Figure 2-4

Many ARC programs allow for themes to be freely set. Selection does not involve a pre-determined ratio of programs; projects that meet the criteria are selected. However, selection tends to focus on research areas where Australia has strengths (Figure 2-7).

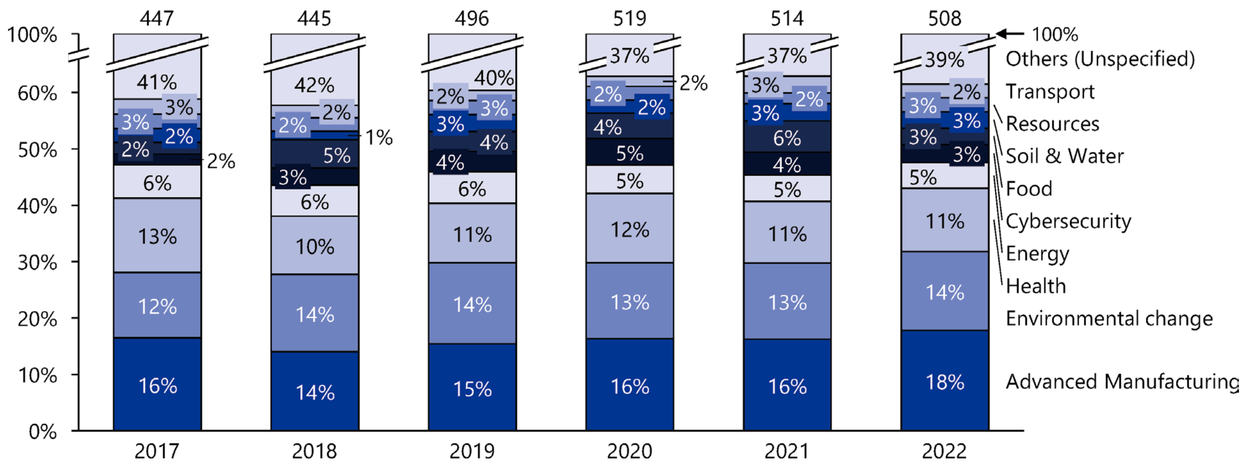


Figure 2-7 Share Per-Theme of Amounts in ARC's Discovery Program (in million AUD)

Source: Same as Figure 2-4

The Discovery and Linkage Programs support basic and applied research, respectively, with several schemes each. The Discovery Program includes "Discovery Projects," "Discovery Early Career Researcher Award," "Future Fellowships,""Australian Laureate Fellowships," "Discovery Indigenous," among others. Details on Discovery Projects and Discovery Early Career Researcher Award are provided below.

Table 2-2 Discovery Program About Discovery Projects

Program Name	Discovery Projects
Purpose	Supports internationally competitive basic research to strengthen Australia's research capability, Also promotes cooperation with overseas researchers, and supports researchers' career development.
Program Overview	Provides grants to basic research projects conducted in universities, etc., across a wide range of fields, including natural sciences, engineering, social sciences, and humanities, that are expected to be innovative or have a high impact.
Program Features	· Supports basic research with international competitiveness and societal impact. · Promotes international collaborations and cooperation among researchers and facilitates career development and community formation among researchers.
Funding Amount	Annual funding from 30,000 to 500,000 AUD
Funding Duration	Up to 5 years
Grant Recipients and Examples (Grant Amount)	· University of Southern Queensland: Research on carbon fiber thermoplastics as next-generation carbon fiber composite materials (390,000 AUD) · University of Technology Sydney: Research on deep learning attacks and active defense (482,000 AUD) · University of Adelaide: Research on the integration of non-metal and metal single-atom catalysts for selective synthesis (530,000 AUD)
Recent Trends	478 proposals (acceptance rate 18.5%) were approved for 2023. The total funding was 221.39 million AUD.

Source: Created by the author from ARC's "Discovery projects"and "More than $221 million ARC Discovery Projects announced for 2023"

Table 2-3 Discovery Program About the Discovery Early Career Researcher Award

Program Name	Discovery Early Career Researcher Award (DECRA)
Purpose	Supports promising early-career researchers and their research by providing an excellent research environment and offering diverse career paths. Also strengthens research capacity in areas of government priority. Also promotes domestic and international research cooperation.
Program Overview	Grants funding to individual research projects undertaken by researchers affiliated with universities, etc., across a broad range of fields, including natural sciences, engineering, social sciences, and humanities.
Program Features	· Targets individual early-career researchers for grants. · Emphasizes research with societal impact and aims to strengthen Australia's research ecosystem.
Funding Amount	Up to 50,000 AUD annually
Funding Duration	Up to 3 years
Recent Trends	200 proposals (acceptance rate 15.0%) were approved for 2023. The total funding was 85.79 million AUD.

Source: Created by the author from ARC's "Discovery Early Career Researcher Award (DECRA)" and "$85 million for 200 projects to support early career researchers"

The Linkage Program supports domestic and international research partnerships between researchers, businesses, and public entities. It aims to create a foundation for commercializing research and generating profits, primarily targeting applied research and experimental development stages. Like the Discovery Program, it includes a variety of programs such as "ARC Centres of Excellence," "Linkage Projects," "Industrial Transformation Research Program," "Linkage Infrastructure, Equipment and Facilities," "Linkage Learned Academies Special Projects," "Special Research Initiatives," "Supporting Responses to Commonwealth Science Council Priorities," "Industry Fellowships," among others[22]. Since Centres of Excellence (COE) will be introduced in Section 2.8, details on Linkage Projects are provided below.

22 ARC, "Linkage Program", accessed January 31, 2023. https://www.arc.gov.au/funding-research/funding-schemes/linkage-program

Table 2-4 Linkage Program About Linkage Projects

Program Name	Linkage Projects
Purpose	Supports internationally competitive research projects and teams that utilize research outcomes to solve challenges and provide opportunities for end-users. Through this support, it promotes research collaboration between universities, etc., and companies or other groups that utilize research. Also strengthens research capabilities in the Australian Government's priority areas.
Program Overview	Provides grants for research projects conducted by universities, etc., in collaboration with companies, etc., across a wide range of fields. Targets projects with a significant social impact that meet the needs of companies, etc.
Program Features	· Supports practical research, including the commercialization of research. · Requires the inclusion of at least one corporate or other partner organization. · Partner organizations must contribute equivalent or greater funding or other resources to the project.
Funding Amount	AUD 50,000 to 300,000 annually
Funding Duration	2 to 5 years
Grant Recipients and Examples (Grant Amount)	· University of New South Wales: Research on the design of advanced alloys for radiation shielding essential for the development of compact fusion reactors (AUD 664,806) · University of Sydney: Research on replacing imported soybean meal used in broiler feed with feed amino acids and local feed (AUD 711,551)
Recent Trends	In the 2022 Round 1, 81 proposals (acceptance rate of 42.0%) were funded, with a total funding amount of AUD 40.08 million. In 2021, three rounds were conducted.

Source: Created by the author from ARC's "Linkage Projects" and "$40 million ARC Linkage Projects drives collaboration and innovation"

2.3.2 National Health and Medical Research Council (NHMRC)

The NHMRC is an agency under the DHAC and plays a key role in advancing health and medical research in Australia, including promoting and providing grants for medical research. The NHMRC provides evidence-based advice to the government on health promotion and disease prevention. It also has the responsibility of creating specific guidelines on various aspects of health, medicine, health research and environmental health. Additionally, it fosters connections between academia and industry, networking within the research community, and oversees grants and support for medical research outside of the ARC's jurisdiction. The NHMRC's budget, staff numbers, organizational chart, and top management overview are as follows[23].

[23] NHMRC, "Annual Report 2021–22", https://www.nhmrc.gov.au/file/18932/download?token=VD577tSs

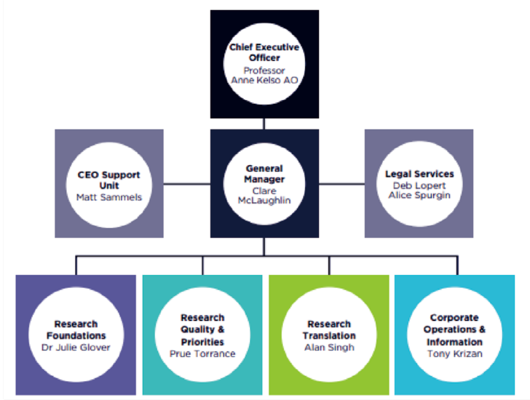
Budget	AUD 903.9 million (FY 2021-2022) ※Total net resourcing and payments (Payments made)
Staff	221 (As of 30 June 2022)
Organizational Chart (As of 30 June 2022)	
Top Management (CEO) Introduction	■ Chief Executive Officer (CEO): Professor Anne Kelso AO Professor Kelso earned her PhD from the University of Melbourne, then worked on immunology research at the Swiss Institute for Experimental Cancer Research, the Walter and Eliza Hall Institute of Medical Research, and the Queensland Institute of Medical Research. From 2000 to 2006, she also served as the Director and CEO of the Cooperative Research Centre for Vaccine Technology. Before joining NHMRC in April 2015, she was the Director of the WHO Collaborating Centre for Reference and Research on Influenza in Melbourne. For her contributions to science, she was awarded the Officer of the Order of Australia (AO) in June 2007.

Figure 2-8 Overview of NHMRC's Organization

Source: Created by the author from NHMRC's "Annual Report 2021–22" and "Senior executive and leadership team"

Basic scientific research is a significant area for the NHMRC, with over 40% of its grants in 2022 going to such research as shown in the following figure.

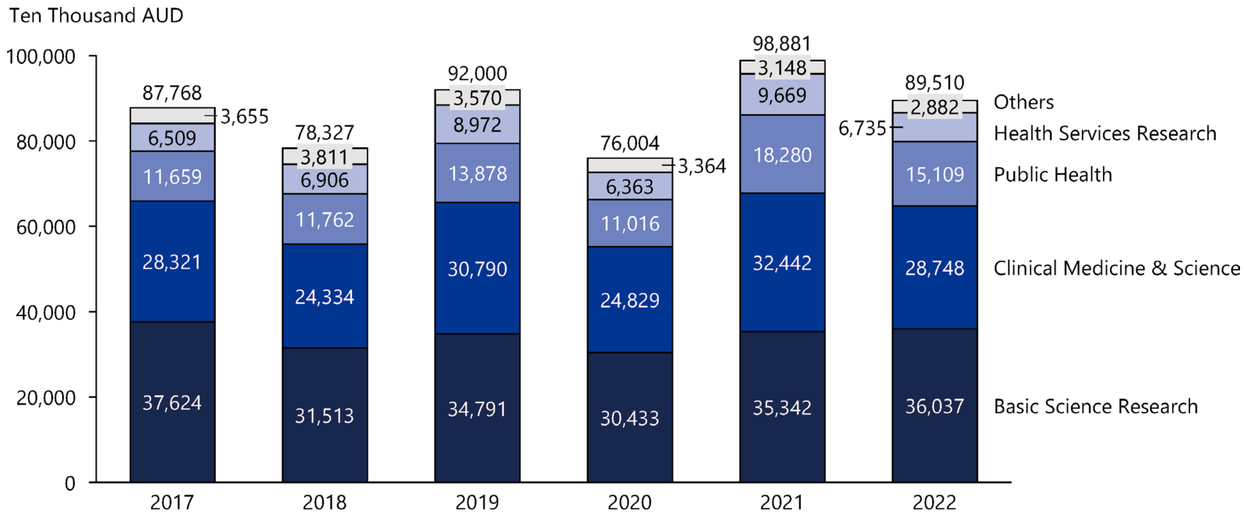


Figure 2-9 Transition of NHMRC's Funding by Research Type

Source: Created by the author from NHMRC's "Outcomes of funding rounds".

The NHMRC offers a variety of grant programs, including "Investigator Grants," "Ideas Grants," "Synergy Grants," "Partnership Projects," "Postgraduate Scholarships," and the "e-ASIA Joint Research Program." Details of basic research being supported by Investors Grants are as follows.

Table 2-5 About Investigator Grants

Program Name	Investigator Grants
Purpose	· Supports innovative and creative research. · Provides researchers at all career stages the opportunity to establish their own research programs. · Ensures flexibility for researchers to pursue important new research directions and collaborate as needed. · Reduces the application and peer review burden on researchers.
Program Overview	Provides grants for basic research projects in a wide range of health and medical fields, including biomedical, clinical, public health, and healthcare services, that are expected to be innovative and have a high impact.
Program Features	· Targets researchers at all career stages. · Supports innovative research with societal impact.
Funding Amount	Varies based on the researcher's career stage and the scale of the research project. Amounts ranged from AUD 80,000 to 800,000 annually in 2023.
Funding Duration	Up to 5 years
Examples of Grant Recipients and Projects (Grant Amount)	University of Melbourne: Research on antigen presentation and adaptive immunity (AUD 3.74 million) Burnet Institute: Transforming midwifery in the Asia-Pacific region through research and innovation to reduce maternal and neonatal mortality (AUD 3.43 million)

Source: Created by the author from NHMRC's "Investigator Grants" and "Outcomes of funding rounds".

2.3.3 Defense Science and Technology Group (DSTG)

The DSTG is an organization within the Department of Defense (DoD) that provides scientific advice and solutions to enhance the capabilities of the defense and national security community, closely associated with Australia's ecosystem of science, technology, and innovation. DSTG has an annual budget of about AUD 408 million and employs around 2,200 staff - primarily scientists, engineers, IT specialists, and technicians, across 8 research facilities[24]. It is Australia's leading grant agency for defense-specific research and the second-largest public research institution after the CSIRO. Due to the nature of the organization, information available to the public is limited; however, this overview will introduce DSTG, its funding, and main funding programs within the available information.

The DSTG executive management body is called the DST leadership team (DLT), which advises the Chief Defence Scientist on DSTG's direction and operations. The DLT supports the Chief Defence Scientist on an individual and

24 DSTG, "ABOUT DSTG", accessed March 28, 2023. https://www.dst.defence.gov.au/discover-dst/about-dst

team level, while managing the DSTG. The DLT consists of the Chief Defence Scientist, three heads of corporate divisions, and seven heads of research divisions. The Chief Defence Scientist chairs the DLT, with each division head reporting directly to them[25].

Professor Tanya Monro, the current Chief Defence Scientist and Capability Manager for Innovation, Science and Technology, received her Ph.D. in Physics from the University of Sydney in 1998, awarded the Bragg Gold Medal for the best Physics Ph.D. thesis in Australia. Before becoming Chief Defence Scientist, she served as the Deputy Vice-Chancellor of Research and Innovation at the University of South Australia, the first Director of the Institute for Photonics and Advanced Sensing, and the first Director of the ARC Centre of Excellence for Nanoscale BioPhotonics at the University of Adelaide[26].

The DSTG was reorganized on July 1, 2022, and is currently composed of the following 10 divisions (Table 2-6).

[25] DSTG, “OUR LEADERSHIP”, accessed March 28, 2023. https://www.dst.defence.gov.au/discover-dst/our-leadership

[26] DSTG, “PROFESSOR TANYA MONRO AC”, accessed March 28, 2023. https://www.dst.defence.gov.au/staff/professor-tanya-monro-ac

Table 2-6 Overview and Focus Areas of DSTG Divisions

	Division	Overview	Focus Area
1	Aerospace Division	Provides innovation and science and technology programs to enhance defense capabilities in the aerospace domain.	Air combat, aviation capabilities, air missile defense, hypersonic weapons, space, Live-Virtual-Constructive environments
2	Cyber, Intelligence, and National Security Division	Provides innovation and science and technology programs for defense intelligence, joint capabilities, and joint operations.	National security, artificial intelligence, quantum, intelligence gathering, cyber, joint electronic warfare
3	Human and Decision Sciences Division	Provides defense science and technology to support human situation awareness, decision-making, control, and protection.	Human system performance, aerospace simulation and force analysis, land force analysis, strategy and joint forces, maritime force analysis, human and combat system analysis
4	Information Sciences Division	Develops defense research capabilities in computational science, autonomy and cyber, communications, and computing.	Adversarial communications, cyber and signal intelligence gathering, cyber warfare operations, information analysis, information interoperability
5	Land and Joint Combat Division	Provides innovation and science and technology programs to support land and joint operations.	Science and technology coordination, integrated forces, electronic warfare, land combat vehicle innovation, enhanced soldiers, long-range precision fire
6	Maritime Division	Provides innovation and science and technology programs to enhance defense capabilities in the maritime domain.	Surface and above-surface warfare, mine warfare and geospatial information, underwater warfare and surveillance, nuclear submarines, multifunction opening sections
7	Platform Division	Provides scientific advice, conducts research, and delivers innovative technologies for existing and future defense challenges.	Aerospace combat performance, aerospace materials, aerospace platform systems, protection and networked autonomy, acoustic signature management, non-acoustic signature management, maritime platform performance, coastal autonomous sensors and systems
8	Research Technology and Operations Division	Provides enabling services for defense research.	Science and technology portfolio, scientific computing, digital science, commercial, occupational health and safety, security, infrastructure (facilities), workforce
9	Science Strategy and Collaboration Division	Advances defense science and technology strategies and policies, producing harmony between defense and the broader science, technology, and innovation ecosystem.	Strategy and policy, governance (resource prioritization and allocation), defense innovation, strategic research, defense science partnerships, defense science communication, Australian Defence Science and Universities Network (ADSUN)
10	Sensors and Effectors Division	Oversees science and technology related to sensing and physical effects (electronic warfare, countermeasures, directed energy, and weapons) for information gathering, surveillance, and reconnaissance.	Electronic warfare operations, surveillance systems, weapon system technology, underwater systems, advanced propulsion systems and weapon effects, CBRN defense

Source: Created by the author from DSTG's "OUR DIVISIONS"

The 2016 Defence White Paper outlined that the Australian Defence Force (ADF) aims to be an organization with the highest level of military capability and sophistication in science and technology in the region[27]. As an initiative to achieve this, the "Defence Innovation Hub" was established to promote collaboration between the defense industry and the defense sector and drive innovation in the defense sector. The platform provides funding for innovative technologies and ideas, supporting collaboration and research and development. Additionally, the Next Generation Technologies Fund (NGTF) was established to improve future defense capabilities through funding necessary for research and development. The NGTF is a fund that invests in technologies with the potential to provide innovative functions to defense, focusing on integrated intelligence, surveillance, reconnaissance, space-related, human performance enhancement, pharmaceutical countermeasures against chemical, biological, radiological, and nuclear (CBRN) threats, multidisciplinary materials science, quantum technology, trusted autonomous systems, cyber, advanced sensors, hypersonics, and directed energy, among others. The NGTF features a variety of support programs, offering flexibility in funding size and duration for promising technologies. Key programs include (1) Grand Challenges, (2) Defence Cooperative Research Centres, (3) University Research Networks, (4) Strategic Research Program, (5) Small Business Innovation Research for Defence, and (6) Australia-US Multi-disciplinary University Research Initiative (AUSMURI), among others[28]. Below is an overview and granting examples of the AUSMURI program, related to basic research.

27 ADF, "Defence White Paper (2016)", https://www.defence.gov.au/about/strategic-planning/defence-white-paper

28 Australian Government: "2018–19 Defense Industry and Innovation Programs Annual Report", https://asiapacificdefencereporter.com/wp-content/uploads/2020/07/Def-Ind-Innovation-Annual-Report_web-Final.pdf

Table 2-7 Overview of AUSMURI

Program Name	ASUMURI (Australia-US Multi-disciplinary University Research Initiative)
Purpose	· A complement to the Multidisciplinary University Research Initiative (MURI) managed by the US Department of Defense, providing grants to Australian universities involved in MURI-selected programs. · It builds international cooperation with the United States through grants.
Program Overview	· Among those selected by MURI, projects involving Australian universities and suitable for AUSMURI are selected by the DoD. · Supports interdisciplinary research teams in Australia by providing up to AUD 1 million per year for 3 years, supporting research projects related to future critical defense capabilities in cooperation with American researchers.
Program Features	· Focused on defense, aiming to promote innovative developments in science and technology. · Operated in conjunction with the US Department of Defense's MURI, encouraging partnerships between universities based in Australia and the United States. · The grant recipients are Australian universities, targeting interdisciplinary research.
Funding Amount	· A total of AUD 25 million over 9 years. · Selected projects receive a grant of up to AUD 1 million per year for 3 years. · A review is conducted at the end of the 3 years, with a possibility of extension for up to 2 additional years. The grant amount remains up to AUD 1 million per year even during the extension.
Funding Duration	3 years (with an additional 2 years if extended)
Themes	Themes are selected by the US MURI. The two grant themes for 2023 are as follows: · Control theory for new quantum error correction. · Building comprehensive cognitive abilities through attention control.

Source: Created by the author from Australian Government's "Australia-US International Multidisciplinary University Research Initiative (AUSMURI)"

Table 2-8 Examples of AUSMURI Funded Projects

Project Name	"Noise-Canceling Headphones" for Quantum Computers
Grant Start Period	Fiscal Year 2018
Grant Period	3 years (initially)
Grant-Receiving Institution	Australia: Griffith University, UNSW, University of Technology Sydney United States: Duke University, University of Oregon, Massachusetts Institute of Technology, etc., totaling 7 institutions
Grant Amount	AUD 3 million (AUD 1 million per year for 3 years)
Project Overview	Information processed by quantum computers is fragile, and these computers require protection from environmental noise to operate properly. A solution for shielding qubits from environmental noise involves using spectator qubits to cancel out noise from around the data qubits. Research and development of advanced machine learning algorithms that allow spectator qubits to instantly determine the best method to cancel out detected noise.

Source: Created by the author from Australian Government's "2018–19 Defence Industry and Innovation Programs Annual Report".

Following the 2016 Defence White Paper, DSTG announced the More, together: Defence Science and Technology Strategy 2030 in 2020[29] and launched a new research grant program called Science, Technology and Research (STaR) Shots.[30]

The Defence Science and Technology Strategy 2030 aims to identify priorities and place focus on large-scale science and technology programs, expand scale through domestic science and technology-related companies and international partnerships, and build superior, impactful capabilities through innovation. There are three pillars to these goals: The One Defence S&T Capability pillar involves leading, shaping and nurturing Australia's national defence S&T enterprise and the coordination of S&T capability to support defence needs. The Brilliant People, Collaborative Culture pillar involves developing a highly skilled and collaborative workforce, recognizing diversity in partnerships and building shared culture. Finally, the Outstanding Research Infrastructure Powering Innovation Pillar involves providing the necessary physical and digital research environments, building defence precincts and embracing opportunities to share infrastructure.

STaR Shots focuses on technological innovations and military capability enhancements considered most critical in the defense field, identifying projects and prioritizing them based on strategic objectives. It promotes joint research and development activities in collaboration with the Ministry of Defence, industry, academia, and international partners. STaR Shots projects require at least one sponsor from ADF senior officers with three-star rank or above, ensuring research does not remain theoretical but is utilized by the military as a final outcome. Identified STaR Shots receive commitments from DoD and significant research funding from the NGTF, etc., to promote their research. Six STaR Shots projects have been launched as initial efforts (Table 2-9).

Table 2-9 Overview of STaR Shots Projects

	Project Name	Project Overview
1	Resilient Space Multi-Mission	Utilizes low Earth orbit satellite constellations to provide resilient global communications, PNT (Positioning, Navigation, and Timing) information, and geospatial intelligence (GEOINT) directly to military personnel.
2	Information Warfare	Providing integrated information in human, information, and physical domains in a competitive environment.
3	Agile Command and Control	Building superior capabilities at all levels to understand, shape, and dominate the future multi-domain combat space.
4	Quantum-Assured PNT	Securing positioning, navigation, and timing in competitive environments.
5	Activities in CBRN Environments	Enabling the military to operate safely and effectively in the presence of CBRN threats.
6	Remote Subsea Surveillance	Developing upstream/downstream sensors, information processing, communication, and data fusion systems to provide remote surveillance of the subsea environment within Australia's maritime jurisdiction.

Source: Created by the author from DSTG's "STRATEGY | STaR Shots"

[29] DSTG, "STRATEGY | Defence Science and Technology Strategy 2030", Accessed March 28, 2023. https://www.dst.defence.gov.au/strategy/defence-science-and-technology-strategy-2030

[30] DSTG, "STRATEGY | STaR Shots", Accessed March 28, 2023. https://www.dst.defence.gov.au/strategy/star-shots

2.3.4 Other Funding Agencies

(1) Australian Renewable Energy Agency (ARENA)

ARENA was established by the Australian Government on July 1, 2012, aiming to facilitate the transition to net-zero emissions through innovations in pre-commercial technology, etc.

Utilizing its expertise and deep understanding of the renewable energy sector, ARENA has actively provided funding to projects struggling to launch and new technologies at risk of moving overseas, offering pathways to commercialization. Since 2012, ARENA has supported 632 projects with AUD 1.96 billion in funding, drawing approximately AUD 8.81 billion in investments to the domestic renewable energy industry[31].

ARENA supports the innovation process from research and demonstration projects through to large-scale commercial deployments. However, most of its supported projects are at the commercialization stage, and it has limited involvement in basic research.

(2) Clean Energy Finance Corporation (CEFC)

The CEFC is a government agency established to facilitate financial flows into the renewable energy sector, providing funds to accelerate the transition to renewable energy and address climate change.

As a major provider of funding for achieving lower CO_2 emissions in Australia, the CEFC celebrated its 10th anniversary of investment activities and achieved over AUD 10 billion in investment commitments in 2022. The CEFC aims to transition Australia to net-zero emissions by 2050 through large investments.[32]

The CEFC invests in a diverse range of projects across Australia. It provides research funding and investment for the introduction of various scales of renewable energy, as well as new and proven technologies, but its involvement in basic research is limited.

(3) Future Fund Management Agency (FFMA)

The FFMA is a government fund in Australia, established in 2006 to manage the government's assets and execute investment strategies to strengthen the country's long-term financial foundations. The FFMA manages assets of special-purpose public asset funds, including the Future Fund, Medical Research Future Fund, Aboriginal and Torres Strait Islander Land and Sea Future Fund, Future Drought Fund, Emergency Response Fund, and DisabilityCare Australia Fund. These funds each have a mission to generate certain returns through investments related to relevant businesses and technologies[33].

(4) Medical Research Future Fund (MRFF)

The Medical Research Future Fund (MRFF) is a long-term investment fund of AUD 20 billion, aiming to innovate in the Australian health and medical sector, improve people's lives, develop the economy, and contribute to the sustainability of the healthcare system.

31 ARENA, "Funding Opportunities", viewed on January 26, 2023. https://arena.gov.au/funding/

32 CEFC, "Where we invest", viewed on January 26, 2023. https://www.cefc.com.au/where-we-invest/

33 FFMA, "Our Funds", viewed on January 26, 2023. https://www.futurefund.gov.au/about-us/our-funds

Additionally, the MRFF advises the Australian Government on how to allocate research funding in the health and medical sector. The Minister for Health and Aged Care decides on the use of the fund, considering the MRFF's strategies and priorities. Funding from the MRFF focuses on bridging research and commercialization projects[34].

(5) Science and Industry Endowment Fund (SIEF)

SIEF is a funding agency closely related to the CSIRO and was established in 1926 at the same time as the CSIR, the CSIRO's predecessor. The SIEF supports scientific research that meets the following conditions:

1. Activities in the field of natural or applied science that extend knowledge, including the practical application of that knowledge.
2. Supporting industries and promoting social benefits for the national interest and contributing to the achievement of national objectives.
3. Projects aligned with the fund's strategic objectives.

Regular calls for young researcher grant programs (SIEF John Stocker Postdoctoral Fellowship), among others, and occasional large grant programs[35]. An overview of special research programs and examples of grants are introduced below (Table 2-10).

Table 2-10 About the SIEF Special Research Program

Program Name	SIEF Special Research Program
Purpose	Grants under the Special Research Program address funding gaps related to national innovation.
Program Overview	Supports projects that align with SIEF's support objectives and strategic goals but are outside the usual program activities.
Program Features	The grant period and amount are set according to the project's objectives. Large grants of up to AUD 10 million are also provided.
Funding Amount	Varies depending on the project.
Funding Duration	Varies depending on the project.
Grant Recipient Institutions and Examples of Fund Use (SIEF Special Research Program: Synchrotron Science, project completed in 2016)	Grants to the CSIRO to administer and manage an AUD 10 million program over 4 years, enabling researchers from the government, universities, etc., to access the synchrotron. Through this program, access to the synchrotron was provided to federal and Victoria state governments, university personnel, etc., supporting research using the synchrotron. Over four years, the program contributed to research such as: · Development of the Maia detector, using fluorescent X-ray microscopy to detect gold. · Development of cancer treatment drugs through X-ray diffraction. · Elucidation of casein micelles at the nanoscale for producing better milk.

Source: Created by the author from SIEF's "SIEF Special Research Program"

34 MRFF, "Our work", viewed on January 26, 2023. https://www.health.gov.au/our-work/medical-research-future-fund

35 SIEF, "Strategy", viewed on January 26, 2023. https://sief.org.au/about-sief/strategy/

(6) AgriFutures Australia

AgriFutures Australia is a funding agency that addresses the needs of research and development in Australian agricultural and regional communities. AgriFutures Australia aims to support research and innovation in 13 areas (chicken meat, rice, bees and pollination, ginger, tea tree oil, pasture seeds, export fodder, thoroughbred horses, kangaroos, buffalo, deer, goat fiber, laterite), bringing benefits to producers[36]. Its main initiatives are as follows:

1. Investing in research, development, and dissemination to promote the growth and development of emerging agricultural and rural industries with high potential, such as sesame, industrial hemp, and seaweed.
2. Developing and providing programs to address specific workforce and leadership needs of people working in the Australian agricultural sector.
3. Identifying national challenges and opportunities affecting the Australian agricultural sector and developing and providing programs to provide support into the future to address them.
4. Engaging with the global agricultural food innovation system and innovating Australian agricultural food technology.

2.4 Public Research Institutions

This section discusses the CSIRO and ANSTO, the main public research institutions involved in basic research. The latter part introduces representative research institutions engaged in commercial-stage research.

2.4.1 Commonwealth Scientific and Industrial Research Organisation (CSIRO)

The CSIRO is Australia's leading public research institution and is recognized as world-class. It collaborates with many other major research institutions worldwide. The CSIRO also manages national research facilities and science and technology infrastructure on behalf of the country along with providing research support. Some of its domestic facilities and research labs as joint-use research facilities accessible to researchers from industry and research institutions both domestically and internationally, with the CSIRO involved in their management and operation.

The CSIRO targets nearly all sectors of primary, secondary, and tertiary industries for its research activities and also possesses functions beyond research activities. An organizational revision was conducted in 2014, and currently, it operates based on the following three business lines:

1. Impact Science: Units focused on critical issues facing the nation.
2. National Collections and Marine Infrastructure: Management of biological collections and marine infrastructure.
3. CSIRO Services: Providing products and services for businesses, government, and communities, including education, publishing, infrastructure technology, small and medium-sized enterprise support, and CSIRO Futures.

The CSIRO has 5,672 staff, and the organizational structure as of 2022 is as follows:

[36] AgriFutures Australia, "About", viewed on January 26, 2023. https://agrifutures.com.au/about/

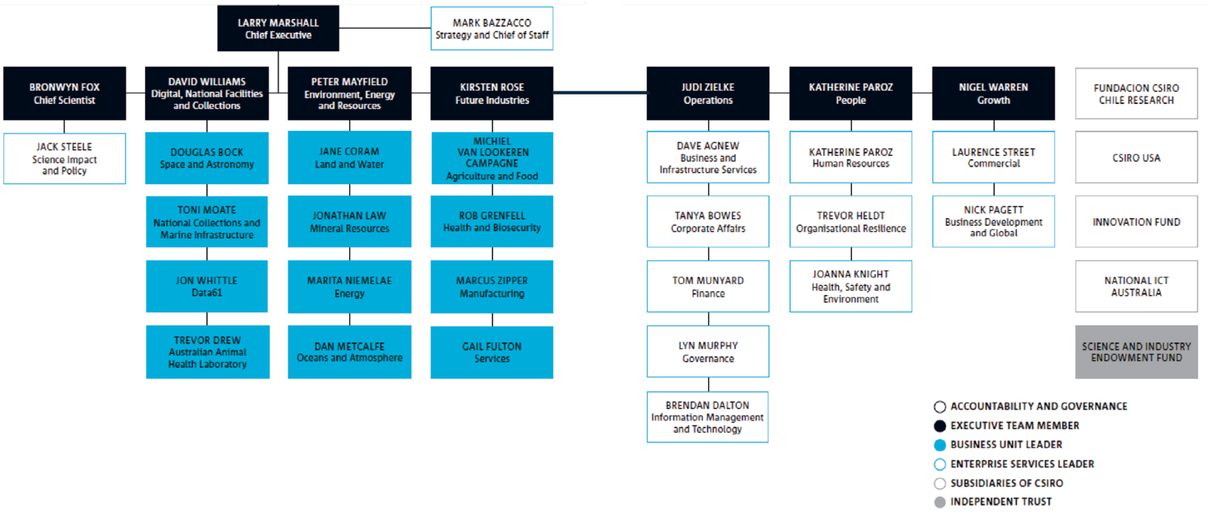


Figure 2-10 The CSIRO's Organizational Structure

Source: Created by the author from CSIRO's "Annual Report 2021-22"

Additionally, the CSIRO's main sources of funding and income are direct funding from the federal government and self-generated income (income from various services, research service fees, rental income from research facilities, profits from stock investments and intellectual property sales, etc.). The amount of funding provided by the federal government in 2022 was approximately AUD 950 million, and self-generated income was approximately AUD 560 million.[37]

In addition to its research functions, it also has funding and support functions for businesses and researchers, as shown below. Some programs are provided in collaboration with the grant agency SIEF (Table 2-11).

[37] CSIRO, "Annual Report 2021–22", https://www.csiro.au/-/media/About/AnnualReport/Images/2021-2022/22-00188_CORP_REPORT_AnnualReport2021-22_WEB_221018.pdf

Table 2-11 Examples of the CSIRO's Funding and Support Programs

Target	Program Overview
Businesses	(1) Innovation Fund The Innovation Fund aims to support startups and SMEs in developing new products and services by utilizing the CSIRO's technologies and research outcomes in fields such as health, food, space, transport, security, and decarbonization, contributing to the growth of the Australian economy and creating employment opportunities. To realize new products and services, the Innovation Fund supports fundraising necessary for research and development. (2) Uniseed Uniseed is a venture fund that provides seed capital, established by the CSIRO in collaboration with domestic universities. It offers funding, expert guidance, and access to networks to support the commercialization of innovative startups and promising technologies.
Researchers	(1) SIEF Ross Metcalf STEM+ Business Fellowship Program This program provides financial assistance to send Early Career Researchers (ECR) from Australian research institutions to companies to commercialize new ideas held by SMEs. While its main goal is the commercialization of research and ideas possessed by SMEs, dispatched researchers can participate in research projects through a two-year fellowship, gaining practical research skills in intellectual property management, project management, leadership, and more through involvement in corporate research and development. (2) SIEF Experimental Development Program (EDP) A joint program by the CSIRO and SIEF, it supports outstanding researchers and research teams in acquiring the skills and knowledge needed to realize the commercialization and business development of technology. Specifically, it provides opportunities to learn about business strategy formulation, project management, intellectual property management, finance, etc.

Sources: Created by the author from CSIRO's "Main Sequence, CSIRO's Innovation Funds" and "SIEF Ross Metcalf STEM+ Business Fellowship", Uniseed, "Uniseed Overview" and SEIF's "Experimental Development Program"

Dr. Larry Marshall, currently serving as the CEO of the CSIRO, was born in Sydney and completed his Ph.D. in Physics at Macquarie University in New South Wales. As a scientist, technology innovator, and business leader, he has been engaged in creating new value and impacts through science for over 25 years, founding and successfully managing six companies in fields such as biotechnology, photonics, telecommunications, and semiconductors, and serving as a director of 20 high-tech companies operating in the United States, Australia, China, and other countries[38].

2.4.2 Australian Nuclear Science and Technology Organisation (ANSTO)

ANSTO is a national nuclear research and development organization under the DISR, serving as the focal point for nuclear research. The organization's expertise is utilized in solving complex problems faced by the industry and in research on national priorities such as the production of radiopharmaceuticals, materials engineering, and water resource management. It also provides expert advice to the government on all matters related to nuclear technology.

ANSTO manages and operates scientific infrastructure, including Australia's only reactor, the open-pool OPAL

38 CSIRO, "Dr. Larry R. Marshall", accessed on January 31, 2023. https://csiropedia.csiro.au/larry-marshall/

reactor, and the Australian Synchrotron, among others. Additionally, it provides grants and support to assist in the commercialization of new technologies. ANSTO's commercialization support gathers experts with a wide range of skills in technology, business, marketing, finance, management, law, etc., to provide extensive support.[39] Its grants are offered in various forms, including technology vouchers[40], technology transfer, and tax incentives for research and development.

2.4.3 Other Research Institutions

(1) Cotton Research and Development Corporation (CRDC)

The CRDC is a research and grant institution under the DAFF, working on cotton research, development, and extension (RD&E) activities for the Australian cotton industry. In addition to its own research, the CRDC invests and grants funds for world-leading research and development through partnerships with the federal government and cotton producers, contributing to the development of the domestic cotton industry and the local community. The CRDC's policies and initiatives are managed based on its Strategic RD&E Plan 2018-23, which outlines five key priorities[41].

1. Improving the productivity and profitability of Australian cotton farms
2. Enhancing the sustainability of cotton cultivation and the competitiveness of its value chain
3. Improving the adaptability of the Australian cotton industry
4. Strengthening partnerships
5. Realizing the impact of RD&E

(2) Fisheries Research and Development Corporation (FRDC)

The FRDC is an agency under the DAFF. It is a research corporation related to the fisheries and aquaculture industries. Similar to the CRDC, the FRDC has research and funding functions and plays a leading role in supporting the sustainability of the fisheries sector and aquatic ecosystems through fisheries research and development.

The FRDC supports the development of the fisheries industry through research projects, incubation and acceleration to verify and develop ideas, events connecting people, and large-scale projects addressing complex challenges[42].

(3) Grains Research and Development Corporation (GRDC)

The GRDC was established in October 1990 under the Primary Industries and Energy Research and Development Act of 1989. The GRDC is a research corporation similar to the CRDC and the FRDC, under the DAFF, with research and funding functions. It invests in and supports projects to improve profitability and productivity in the domestic grain industry.

The GRDC's approach to research and development is outlined in its Research, Development and Extension Plan 2018-23. The GRDC is involved in and supports research, development, and extension to provide enduring profitability for grain

39 ANSTO, "What we do", accessed on January 31, 2023. https://www.ansto.gov.au/about/what-we-do

40 Grant programs for SMEs and startups to cover part of the costs related to research, development, and innovation

41 CRDC, "STRATEGIC RD&E PLAN 2018–2023", https://www.crdc.com.au/sites/default/files/pdf/CRDC%20Strategic%20RD%26E%20Plan%202018-23.pdf

42 FRDC, "About FRDC", accessed on January 31, 2023. https://www.frdc.com.au/about-frdc

producers, focusing on yield improvement, price maintenance/improvement, cost optimization, and risk management[43].

(4) Australian Institute of Marine Science (AIMS)

AIMS is a tropical marine science research institution, working on improving the health of the ocean and protecting coral reefs and other marine habitats from climate change. It conducts research to protect Australian marine habitats, recognizing challenges in tropical marine areas such as Ningaloo Reef, the Top End, and the Great Barrier Reef[44].

(5) Australian Antarctic Division

The Australian Antarctic Division is part of DCCEEW, based in Kingston, Tasmania, and leads the country's Antarctic program. The division's research focuses on climate change, the conservation of wildlife in Antarctica and the Southern Ocean, and the sustainability of Southern Ocean fisheries[45].

2.5 Universities

As mentioned earlier, Australia has 43 universities (40 Australian universities, 2 international universities, and 1 private specialty university). The main role of Australian universities is to provide higher education and conduct research. Although there are fewer universities compared to Japan, each university strives to maintain high quality in both education and research. As a result, although there is variability in research outcomes among domestic universities, each university maintains a certain level of quality.

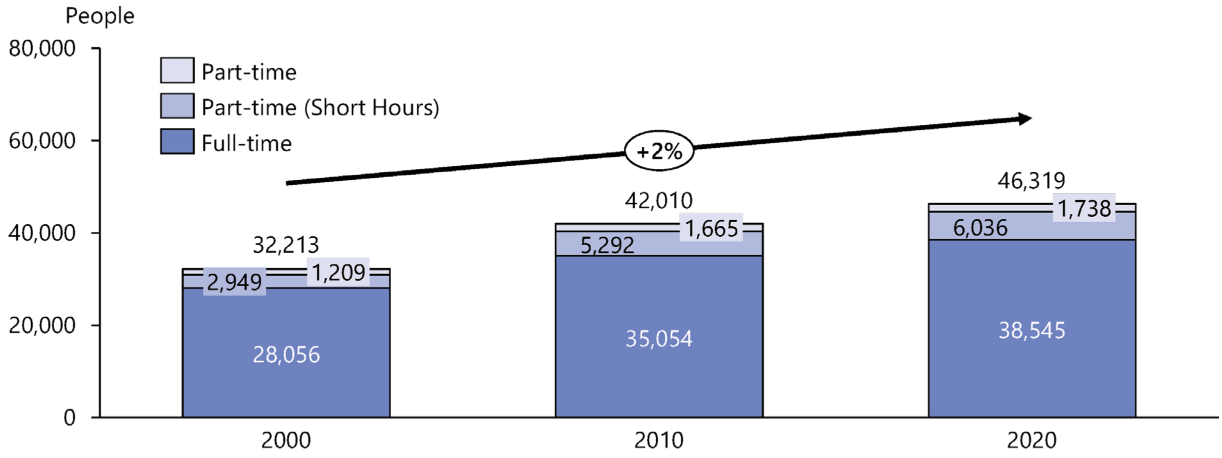
2.5.1 Research Initiatives

In terms of research, universities represent the main carriers of basic research in Australia. The number of research personnel in universities is on an upwards trend (Figure 2-11).

43 GRDC, "About", accessed on January 31, 2023. https://grdc.com.au/about

44 AIMS, "About AIMS", accessed on January 31, 2023. https://www.aims.gov.au/about-aims

45 Australian Antarctic Division, "About us", accessed on January 31, 2023. https://www.antarctica.gov.au/about-us/



*Note: Staff engaged solely in research and those engaged in both teaching and research at universities are converted to FTE (Full-Time Equivalent)

Figure 2-11 Trends in Research Personnel in Australian Universities

Source: Created by the author from DoE's "Selected Higher Education Statistics – 2021 Staff data"

Research and development expenditures in universities are increasing year by year. Moreover, the growth rate of research and development expenditures (8%) is higher compared to the increase in the number of research personnel (2%), suggesting that research and development expenditures per researcher are increasing (Figure 2-12).

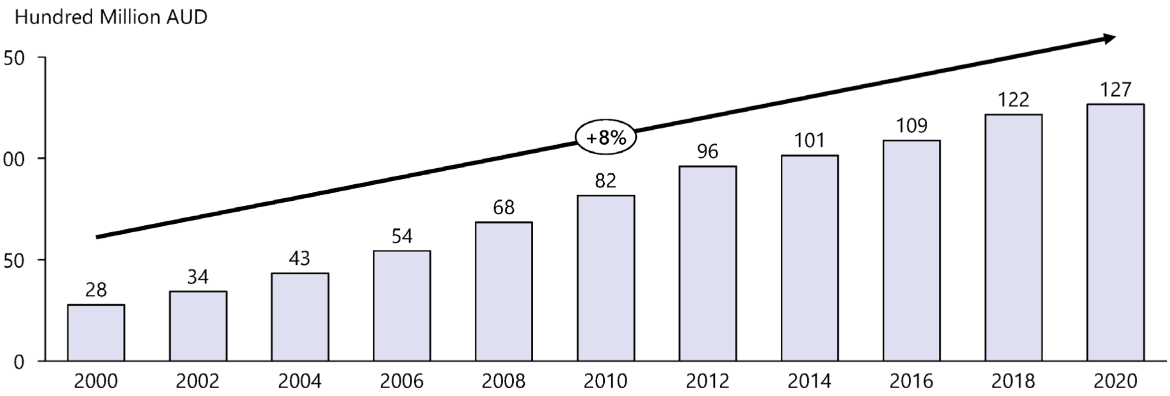


Figure 2-12 Trends in Research and Development Expenditures in Australian Universities

Source: Created by the author from DoE's "Higher education expenditure on R&D by higher education provider"

Examining the breakdown of research and development expenditures, the amounts for basic research, applied research, and experimental development research have all increased, but the share of applied research and experimental development research has grown, rising from a combined 45% in 2000 to 63% in 2020. The commercialization of research and its application in the industry is one of the government's key policies, and the expenditure trends of university research and development funds also indicate a shift in the focus of research stages (Figure 2-13).

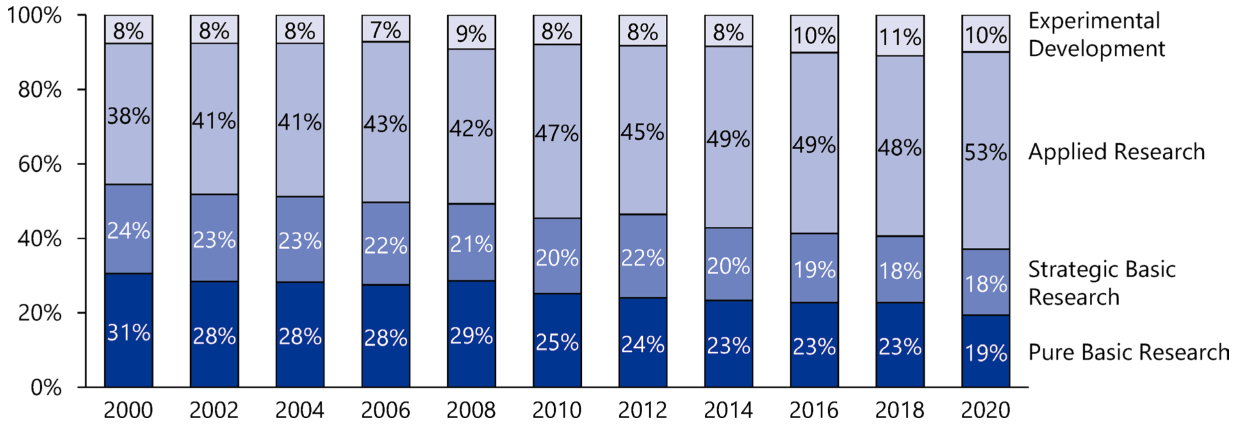


Figure 2-13 Trends in Research and Development Expenditures in Universities (by Research Development Stage)

Source: Same as Figure 2-12

Examining research and development expenditures by university, the top 8 universities are members of the Group of Eight (Go8), accounting for about 60% of the total research and development expenditures of universities.

Comparing the top universities over time, Monash University, known for its strengths in medicine, increased its share from 4% in 2000 to 9% in 2020, a 5-point rise. On the other hand, the Australian National University saw a decrease from 10% in 2000 to 6% in 2020, a 4-point drop (Figure 2-14).

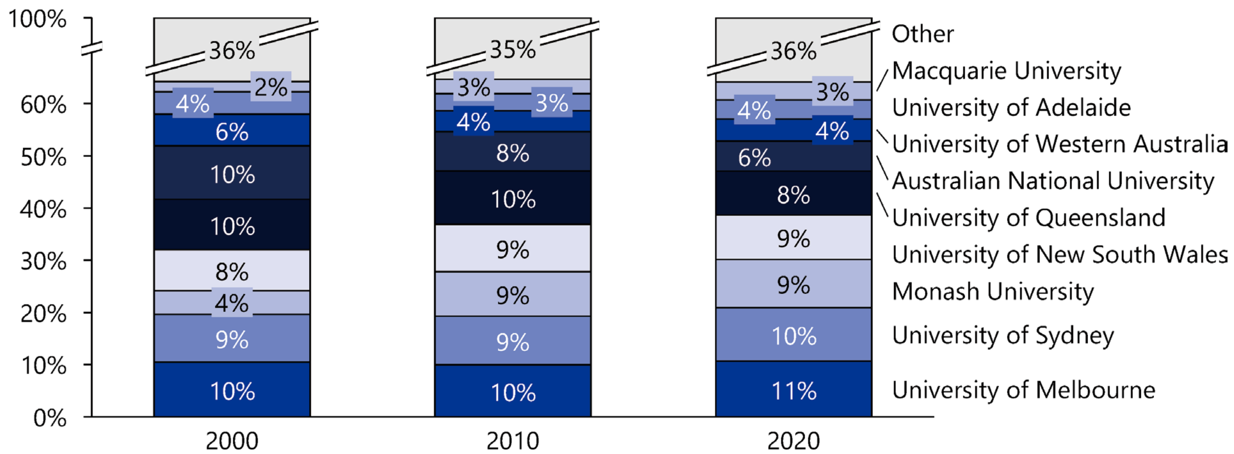


Figure 2-14 Trends in Research and Development Expenditures in Universities (by University)

Source: Same as Figure 2-12

Examining the breakdown of research and development expenditures by field, it is difficult to compare changes under the same conditions due to changes in classification methods, but it can be confirmed that the medical and biotech fields have been priority areas (Figure 2-15).

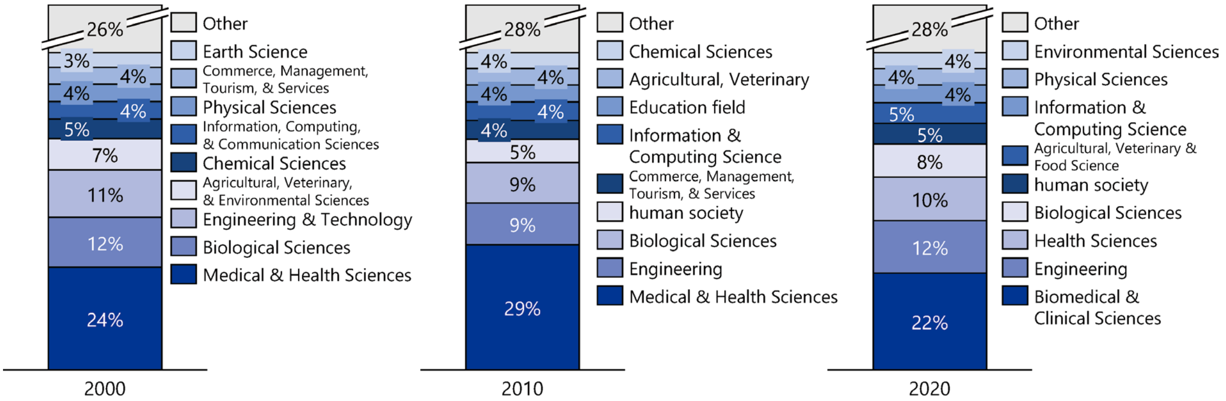


Figure 2-15 Trends in Research and Development Expenditures in Universities (by Research Field)

Source: Same as Figure 2-12

2.5.2 Domestic University Networks

In Australia, there are several university networks, including the previously mentioned Group of Eight (Go8). While there are multiple reasons for forming these networks, one of the key objectives is to influence Science, Technology, and Innovation (STI) policy by presenting a unified stance. Specifically, when public comments are solicited for new STI policies, group members discuss and submit comments as a collective voice, conveying a message with more weight than individual universities can on their own. Additionally, lobbying activities to government agencies carry more weight when conducted as a group. However, reaching a consensus on policies and opinions as a group requires agreement from all members, necessitating a composition of members with similar backgrounds and objectives. As a result, groups with similar backgrounds and shared problem recognition have been formed, such as the Go8, a consortium of universities with research strengths; the Australian Technology Network of Universities (ATN), a consortium of engineering universities; and the Regional Universities Network (RUN), a consortium of universities located in regional areas. The main university networks in Australia and their member universities are as follows:

Table 2-12 Main University Networks and Member Universities

University Network	Member Universities	
Group of Eight Universities (Go8)	· University of Melbourne · Australian National University · University of Sydney · University of Queensland	· University of Western Australia · University of Adelaide · Monash University · University of New South Wales
Australian Technology Network of Universities (ATN)	· Curtin University · Deakin University · RMIT University	· The University of Newcastle · University of South Australia · University of Technology Sydney
Innovative Research Universities (IRU)	· Flinders University · Griffith University · James Cook University · La Trobe University	· Murdoch University · University of Canberra · Western Sydney University
Regional University Network (RUN)	· Charles Sturt University · Central Queensland University · Federation University Australia	· Southern Cross University · University of New England · University of Southern Queensland · University of the Sunshine Coast

Source: Created by the author from ARC's "Diversity within Institutions"

(1) Group of Eight (Go8)

The Go8 consists of leading research universities in Australia. It focuses on influencing the formulation and implementation of long-term sustainable national higher education and research policies and developing elite international alliances and research partnerships[46]. Notably, the Go8, being a gathering of prominent research universities, also has a high rate of competitive funding acquisition, overshadowing other groups (Figure 2-16).

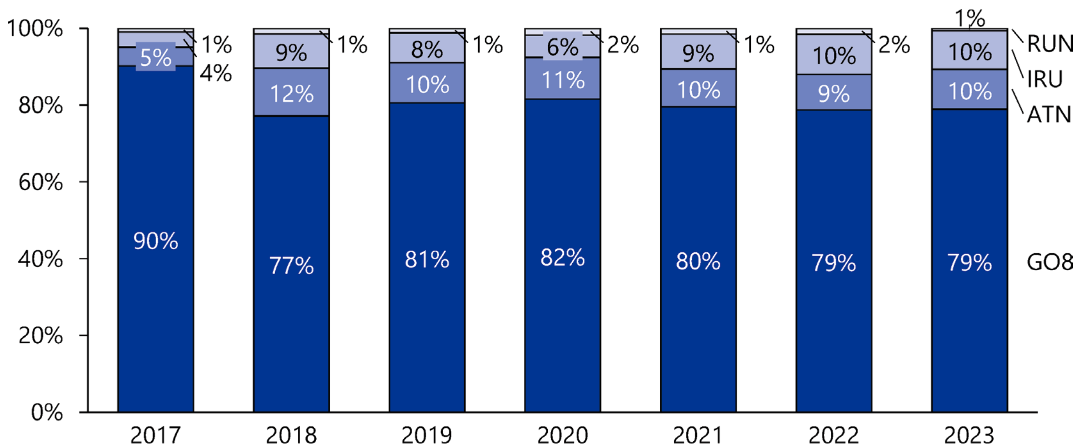


Figure 2-16 Share of ARC Competitive Funding Amongst Four University Networks

Source: Created by the author from ARC's "NCGP Trends: Funding Overview"

46 GO8, "About the Go8", accessed on January 31, 2023. https://go8.edu.au/about/the-go8

(2) The Australian Technology Network of Universities (ATN)

Founded in 1999, the ATN comprises six engineering universities in Australia. It is known for its strengths in innovation and its close collaboration with the industry, boasting many achievements in the field of engineering[47].

(3) Innovative Research Universities (IRU)

The IRU is a coalition of public universities across Australia, engaged in comprehensive education and research that contributes to community development. IRU members focus on basic research, bridging research, and commercialization research, addressing important issues in their communities and national problems[48].

(4) Regional Universities Network (RUN)

RUN is a network consisting of seven universities located in regional Australia. It has strong connections with regional area industries, such as agriculture and mining, and works on solving issues rooted in regional areas[49].

2.6 Researchers

This section organizes the main researchers and research institutions by field in Australia, introducing representative and promising researchers.

2.6.1 Institutions Main Researchers are Affiliated

Referencing the article "Research 2023: These are the top researchers and institutions in 250 fields of research" (Research Magazine 2023) published annually by The Weekend Australian, published by Nationwide News, this section organizes research institutions with a significant number of leading researchers in five fields: engineering & computer science, chemistry & materials science, health & medical chemistry, physics & mathematics, and life & earth sciences (Table 2-13). The article selects 250 top researchers in Australia across 250 areas based on the number of citations of papers published in the top 20 journals in each field over the past five years. While public research institutions like the CSIRO and ANSTO are partially included in the table below, most are universities, with research universities belonging to the GO8 constituting the majority.

47 ATN, "About us", accessed on January 31, 2023. https://atn.edu.au/about-us/

48 IRU, "About us", accessed on January 31, 2023. https://iru.edu.au/purpose/

49 RUN, "WHO ARE WE", accessed on January 31, 2023. https://www.run.edu.au/who-are-we/

Table 2-13 Research Institutions with a High Number of Top Researchers

Engineering & Computer Science	Chemistry & Material Science	Health & Medical Chemistry	Physics & Mathematics	Life Science & Earth Science
· UNSW ※1 · University of Queensland ※1 · University of Technology Sydney ※2 · RMIT ※2 · Monash University ※1 · Curtin University ※2 · University of Melbourne ※1	· UNSW ※1 · Monash University ※1 · University of Queensland ※1 · University of Adelaide ※1 · Curtin University ※2 · University of Sydney ※1 · University of Melbourne ※1 · ANSTO ※3	· Monash University ※1 · UNSW ※1 · University of Queensland ※1 · University of Sydney ※1 · University of Melbourne ※1	· Australian National University ※1 · Monash University ※1 · Curtin University ※2 · Macquarie University · University of Sydney ※1	· University of Queensland ※1 · CSIRO ※3 · University of Sydney ※1 · Monash University ※1 · Curtin University ※2 · Australian National University ※1 · University of Western Australia ※1

※ 1: GO8 member universities, 2: ATN member universities, 3: Public Research Institutions

Source: Created by the author from The Weekend Australian's "RESEARCH MAGAZINE 2023: Our top 250: celebrating the best. These are the top researchers and institutions in 250 fields of research"

2.6.2 Prominent Researchers

This section introduces distinctive researchers in the five fields mentioned above. Research Magazine 2023 selects one characteristic researcher from among the domain leaders in each field. The researchers introduced for each field below is based on its selection for 2023.

(1) Engineering & Computer Science Field

Dr. Cuie Wen is a leading researcher in the field of Biomedical Technology and was selected as a representative researcher in the field of Engineering & Computer Science by Research Magazine 2023.

Table 2-14 Overview of Professor Cuie Wen

Name	Cuie Wen
University Name	RMIT University
Position	Professor of Biomaterials Engineering
Specialization	Composite Materials, Metallurgy, Titanium
Education	· 1992 Ph.D., Huazhong University of Science and Technology · 1984 Graduated from Huazhong University of Science and Technology (Materials Science)
Career & Experience	· From 2014: Professor of Biomaterials Engineering at RMIT University · 2010 to 2014: Professor of Surface Engineering at Swinburne University of Technology · 2003 to 2010 Associate Professor at Deakin University Note: Before moving to Australia, worked at the National Institute of Advanced Industrial Science and Technology in Japan
Awards	· RMIT Academy Fellow (2018) · RMIT Vice-Chancellor's Award for Research Excellence (2017) · RMIT Distinguished Professor (2016)
Major Publications & Papers (Citations)	· Processing of biocompatible porous Ti and Mg (528) · High Energy Density Metal-Air Batteries: A Review (336) · A new look at biomedical Ti-based shape memory alloys (298)
Number of Citations	18,637
h-index	70

Source: Created by the author from RMIT University's "Professor Cuie Wen" and Google Scholar (as of March 15, 2023)

(2) Introduction of a Prominent Researcher in the Field of Chemistry & Materials Science

Dr. Evatt Hawkes is a top researcher in the field of Combustion & Power and was selected as a representative researcher in the field of Chemistry & Materials Science by Research Magazine 2023.

Table 2-15 Overview of Professor Evatt Hawkes

Name	Evatt Hawkes
University Name	University of New South Wales (UNSW)
Position	Professor of Mechanical Engineering
Specialization	Thermodynamics, Combustion, Mechanics
Education	· 2002 to 2007: Postdoc at Sandia National Laboratories (Combustion Research Facility), California, USA · 1996 to 2001: Ph.D., University of Cambridge (Cambridge Australia Trust Scholar, European Gas Turbines Scholarship) · 1995: Graduated from the University of Western Australia, School of Engineering
Career & Experience	· 2016: Professor at UNSW · 2011 to 2015: Associate Professor & ARC Future Fellow at UNSW · 2007 to 2011: Senior Lecturer at UNSW
Awards	· Fellow of the Australian Fluid Mechanics Society (2021) · Selected as the first cohort of fellows of the Combustion Institute (youngest by year of doctorate) (2018) · ARC Future Fellowship (2011) · David Warren Travelling Fellowship (ANZ Section of the CI) (2008)
Major Publications & Papers (Citations)	· Terascale direct numerical simulations of turbulent combustion using S3D (420) · Structure of a spatially developing turbulent lean methane–air Bunsen flame (273) · Direct numerical simulation of hydrogen-enriched lean premixed methane–air flames (213)
Number of Citations	9771
h-index	51

Source: Created by the author from The Combustion Institute's "Evatt R. Hawkes" and Google Scholar (as of March 15, 2023)

(3) Introduction of a Prominent Researcher in the Field of Health and Medical Chemistry

Dr. Edward Holmes is a top researcher in the field of molecular biology and is recognized for being one of the first to discover the COVID-19 virus. He was selected as a representative researcher in the health and medical chemistry field by Research Magazine 2023.

Table 2-16 Overview of Professor Edward Holmes

Name	Edward Holmes
University Name	University of Sydney
Position	Professor of Virology
Specialization	Viruses, Genes, Genomes
Education	· 1990: Ph.D. in Philosophy, Cambridge University · 1986: Graduated from University College London (Anthropology)
Career & Experience	· 2012 to present: Professor of Virology at the University of Sydney · 2005 to 2012: Professor at Pennsylvania State University · 1993 to 2004: Lecturer at Oxford University · 1991 to 1993: Postdoctoral Research Fellow at the University of Edinburgh · 1990 to 1991: Postdoctoral Research Fellow at UC Davis.
Awards	· Australian Prime Minister's Prize for Science (2021) · Symbiont Award (jointly with Professor Yong-Zhen Yang) (2021) · NSW Premier's Prize for Science & Engineering (2020) · Fellow of the Royal Society, UK (2017) · ARC Laureate Fellowship (2017)
Major Publications & Papers (Citations)	· Genomic characterization and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. (5012) · A new coronavirus associated with human respiratory disease in China. (4224)
Number of Citations	127,174
h-index	161

Source: Created by the author from University of Sydney's "Professor Edward Holmes" and Google Scholar (as of March 15, 2023)

(4) Introduction of Prominent Researchers in the Fields of Physics and Mathematics

Dr. Kamila Kochan is a leading researcher in the fields of spectroscopy and molecular physics, focusing on the study of infectious diseases using biological materials, and was selected as a representative researcher in the fields of physics and mathematics by Research Magazine 2023.

Table 2-17 Overview of Dr. Kamila Kochan

Name	Kamila Kochan
University Name	Monash University
Position	Research Fellow
Specialization	Molecular Biology & Genetics (Spectroscopy, IR, RAMAN, AFM-IR)
Education	Completed Ph.D. at Jagiellonian University
Career & Experience	Research Fellow at Monash University
Awards	-
Major Publications & Papers (Citations)	RAMAN Spectroscopy of Lipids: A review (711) RAMAN and Infrared Spectroscopy of Carbohydrates (561) Analytical Techniques in Lipidomics: State of The Art (99)
Number of Citations	2444
h-index	22

Source: Created by the author from Monash University's "Dr. Kamila Kochan" and Google Scholar (as of March 15, 2023)

(5)Introduction of a Prominent Researcher in the Fields of Life Sciences and Earth Sciences

Dr. Jodi Rowley is a leading researcher in the field of zoology and was selected as a representative researcher in the fields of life sciences and earth sciences by Research Magazine 2023, due to her work on the conservation of amphibians at risk of extinction.

Table 2-18 Overview of Dr. Jodi Rowley

Name	Jodi Rowley
University Name	University of New South Wales (UNSW)
Position	Adjunct Fellow
Specialization	Herpetology
Education	· 2007: Ph.D. from James Cook University · 2002: Bachelor of Environmental Science from UNSW
Career & Experience	· Currently, an Adjunct Fellow at UNSW · 2008 to present: Senior Research Fellow and Curator of Amphibian & Reptile Conservation Biology at the Australian Museum
Awards	-
Major Publications & Papers (Citations)	· Behavior of Australian rainforest stream frogs may affect the transmission of chytridiomycosis (167) · Hot bodies protect amphibians against chytrid infection in nature (146) · Impending conservation crisis for southeast Asian amphibians (127)
Number of Citations	3175
h-index	34

Source: Created by the author from UNSW's "Dr Jodi Rowley" and Google Scholar (as of March 15, 2023)

2.7 Trends in International Collaboration

This section reviews Australia's major international joint research partners and organizes the changes over the past decade. Australia's primary international co-authoring partners are the United States, China, and the United Kingdom. In particular, China has increased its share by nearly 15 points compared to ten years ago, holding a share equivalent to that of the top-ranking United States. All of the Western countries (excluding the United States) in Australia's top 10 have increased their share of co-authorship over the past decade. By comparison, Japan's share has decreased from 5.8% to 5.6%, and its ranking as an international co-authoring country has dropped from 8th to 10th, indicating that, from Australia's perspective, Japan's presence may be declining (Figure 2-17).

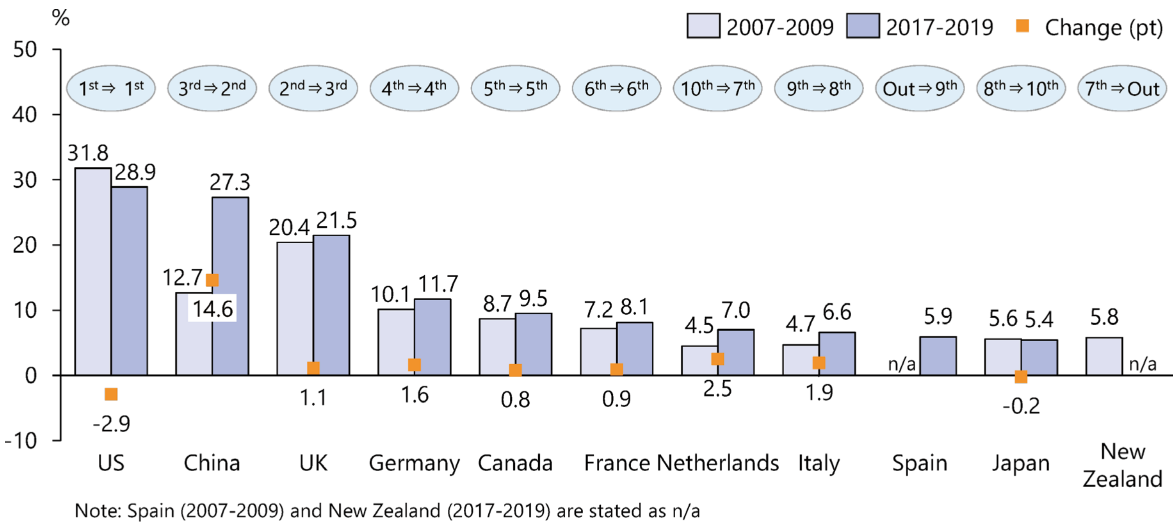


Figure 2-17 Primary International Co-authoring Partner Countries for Australia (All Fields; Share & Ranking of Co-authorship)

Source: Nishikawa Kai et al. (2021) "Benchmarking Scientific Research 2021, NISTEP Research Material, No. 312.", Ministry of Education, Culture, Sports, Science and Technology's National Institute of Science and Technology Policy, created by the author

2.8 Research Bases and Platforms

This section discusses research platforms and research bases (centers) aimed at promoting research and development with partners such as other research institutions and companies. A research platform is a foundation that supports joint research activities among researchers, sharing information and resources, aimed at enhancing collaborations between academia, industry, and government both domestically and internationally, benefiting the Australian research community. However, a research base refers to facilities or locations for conducting research activities in specific fields. Research bases accumulate resources for the creation of academic knowledge, technological development, and innovation, aiming to advance knowledge and technology in their fields. However, both research platforms and bases support research and collaboration, making it difficult to distinctly categorize them in some cases.

Australia has multiple programs to support the formation of research platforms and bases, as well as programs to support research collaborations. This section introduces ARC Centres of Excellence (COE), which supports funding for research bases, and the Department of Education's National Collaborative Research Infrastructure Strategy (NCRIS), along with other unique research collaboration support programs.

2.8.1 Australian Research Council Centres of Excellence (COE)

The COE program was established by the ARC in 2011. Included in the Linkage Program, it provides research funding to encourage joint research in excellent studies (Table 2-19). Over 1 billion AUD in research funding has been approved to date, with 384.9 million AUD approved in 2023. The COE operates on a 3-year cycle (up to 7 years), supporting a wide range of fields such as science, technology, equality, science, environment, biotechnology, etc.

Table 2-19 Overview of Centres of Excellence (COE)

Funding Agency	ARC
Purpose	Enhances and develops Australia's excellent research through innovative joint research and increases Australia's research capabilities in various fields.
Program Overview	Part of the Linkage Program, with 11 grants totaling 384.9 million AUD approved in 2023. Fields receiving significant funding include physical sciences (3 grants) and Indigenous studies (2 grants). Also plans international cooperation with 27 countries, 69 projects, with the main partners being the United States (11 projects), the United Kingdom (7 projects), Germany (7 projects), and Japan with 2 projects.
Program Features	Grants are made to organizations, not individual researchers or research teams. Calls for proposals are made approximately every 5 years (last call in 2019).
Funding Amount	Up to 70 million AUD
Funding Duration	Maximum of 7 years (3-year cycle)

Source: Created by the author from ARC's "ARC Centres of Excellence"

The program starting in 2023 received 101 initial applications, of which 17 submitted formal applications, and the following 11 were selected as COE.

Table 2-20 List of COEs Starting in 2023

Themes	Managing Institution	Centre Director	Grant Amount (AUD)
COE for Indigenous and Environmental Histories and Futures	James Cook University	Professor Sean Ulm	$35,000,000
COE for the Elimination of Violence Against Women	Monash University	Professor Jacqui True	$34,999,990
COE for the Weather of the 21st Century	Monash University	Professor Christian Jakob	$35,000,000
COE in Optical Microcombs for Breakthrough Science	RMIT University	Professor Arnan Mitchell	$34,948,820
COE for Gravitational Wave Discovery	Swinburne University of Technology	Professor Matthew Bailes	$35,000,000
COE in Plants for Space	University of Adelaide	Professor Matthew Gilliham	$35,000,000
COE for the Mathematical Analysis of Cellular Systems	University of Melbourne	Professor Michael Stumpf	$35,000,000
COE for Carbon Science and Innovation	University of New South Wales	Professor Liming Dai	$35,000,000
COE for Green Electrochemical Conversion of Carbon Dioxide	University of Queensland	Professor Xiwang Zhang	$34,956,464
COE for Indigenous Futures	University of Queensland	Professor Brendan Hokowhitu	$35,000,000
COE in Quantum Biotechnology	University of Queensland	Professor Warwick Bowen	$35,000,000

Source: Same as Table 2-19

Below is an overview of the COE for Carbon Science and Innovation, which includes participation from Japanese universities.

Table 2-21 Overview of COE for Carbon Science and Innovation

Project Theme	COE for Carbon Science and Innovation
Project Overview	This center aims to develop carbon-based catalysts for green chemistry, which will enable renewable energy, CO2 capture, and emission reductions. It seeks to transform the fundamental science of carbon materials through pioneering data-driven atomic-level precision synthesis and multi-scale analysis.
Representatives and Key Members	Managing Institution: University of New South Wales Center Director: Professor Liming Dai Additionally, 26 research institutions and universities from Australia, the USA, the UK, Germany, and other countries are collaborating in the COE. The University of Tsukuba is participating from Japan.
Project Duration	2023 to 2030 years
Funding Amount	35 million AUD
Other Characteristics	The expected outcomes of this project include the development of new technologies in the energy, environment, and green chemical industries, utilizing abundant sunlight, seawater, and waste materials. Through industry collaboration, it aims to nurture the next generation of innovators, helping the carbon industry to address significant socio-economic challenges and ultimately achieve the goal of zero carbon emissions.

Source: Same as Table 2-19

2.8.2 National Collaborative Research Infrastructure Strategy (NCRIS)

NCRIS is a program that supports domestic researchers, industry, and their partners to access cutting-edge national research infrastructure (NRI). NCRIS includes both tangible assets, like supercomputers and microscopes, and intangible assets, such as collected data and software platforms. The Australian government plans to invest 4 billion AUD in its infrastructure from 2018 to 2029, with a planned expenditure of 283 million AUD for the 2022-2023 fiscal year. Infrastructure investment plans are updated every five years based on the NRI Roadmap, with the most current at the time of authorship being the 2021 Roadmap, which is focused on maintenance of and access to NRI[50]. The eight priority areas are as follows:

Table 2-22 Key Themes in the NRI Roadmap

1. Resource Technology & Mineral Processing	2. Food & Beverage	3. Pharmaceuticals	4. Recycling & Clean Energy
5. Defence	6. Space	7. Environment and Climate	8. Frontier Technologies and Advanced Manufacturing

Source: Created by the author from DOE's "2021 National Research Infrastructure Roadmap"

[50] DoE, "2021 National Research Infrastructure Roadmap", accessed March 28, 2023. https://www.education.gov.au/national-research-infrastructure/2021-national-research-infrastructure-roadmap

Currently, NCRIS is funding 24 projects, supporting the maintenance of research infrastructure and research platforms[51]. The names and summaries of the 24 funded projects are as follows:

Table 2-23 List of Programs & Infrastructure Funded by NCRIS (as of March 2023)

Project/Infrastructure Name	Overview
Astronomy Australia Ltd (AAL)	Supports Australian astronomers by providing access to high-functioning observatories and high-performance computers.
Atlas of Living Australia (ALA)	Manages Australia's national biodiversity database, assisting researchers to access data on plants, animals, fungi, etc.
AuScope	Supports the Australian earth and geospatial science community by facilitating access to data about the Earth.
Australian Centre for Disease Preparedness (ACDP)	Provides researchers studying human and animal diseases with infrastructure equipped with the highest level of safety measures.
Australian Community Climate and Earth System Simulator (ACCESS)	Uses various environmental data, combining it to enable weather forecasting and support climate change research.
Australian National Fabrication Facility (ANFF)	Provides infrastructure for researchers to process hard materials like metals and ceramics, as well as soft materials like polymers. Also offers training.
Australian Plant Phenomics Facility (APPF)	Supports the development of new and improved crops by providing expertise and data through the measurement of plant physical properties.
Australian Research Data Commons (ARDC)	Supports researchers' access to data and the use of research analysis platforms. Also provides expertise and training.
Australian Urban Research Infrastructure Network (AURIN)	Supports access to detailed and curated data about Australian towns and cities.
Bioplatforms Australia (BPA)	Supports researchers conducting research on DNA, proteins, etc., by providing access to research equipment.
Heavy Ion Accelerators (HIA)	Supports access to the world's highest standard heavy ion accelerator for researchers and the industry.
Integrated Marine Observing System (IMOS)	Publishes data for marine research collected by a national system that gathers data about the seas around Australia.
Microscopy Australia (MAU)	Supports access to advanced microscopes and expertise nationwide.
National Computational Infrastructure (NCI)	Provides Australian researchers, government, and industry with access to high-performance computing.
National Deuteration Facility (NDF)	Is the only facility in Australia offering deuteration, providing researchers with a setting for chemical and biological research.
National Imaging Facility (NIF)	Provides cutting-edge imaging equipment and expertise for human, animal, plant, and material research.

51 DoE, "National Collaborative Research Infrastructure Strategy (NCRIS)", accessed March 28, 2023. https://www.education.gov.au/ncris

National Sea Simulator (SeaSim)	An advanced marine research aquarium facility, providing a research environment for researchers and collaborators at the Australian Institute of Marine Science.
Nuclear Science Facilities (NSF)	Provides access to neutron beams and accelerators capable of sample analysis at the subatomic level.
Pawsey Supercomputing Centre (Pawsey)	Provides domestic researchers with a high-performance computing environment.
Phenomics Australia (PA)	Provides cell, tissue, and animal models for disease research to researchers domestically and internationally.
Population Health Research Network (PHRN)	Links together and provides various national data to improve the health and welfare of the population.
Southern Coastal Research Vessel Fleet (Coastal Vessels)	Provides a survey vessel used to monitor the seas around Australia.
Terrestrial Ecosystem Research Network (TERN)	Collects environmental data and samples from across the country using remote sensing technologies like drones and satellites and shares the data.
Therapeutic Innovation Australia (TIA)	Supports researchers in discovering new treatments in the health sector.

Source: Created by the author from DoE's "Funded research infrastructure projects"

2.8.3 Other Collaboration Enhancement Programs

(1) Cooperative Research Centers Program (CRC)

The CRC, established in 1990, is a program that provides funding for industry-led collaborations (joint research partnerships) between industry, researchers, and users to solve problems faced by the industry. The CRC involves large-scale collaborations established by companies and multiple universities or research institutions, with programs lasting up to 10 years[52].

(2) Cooperative Research Centers Projects (CRC-P)

CRC-P, a program similar to CRC, supports small-scale and short-term joint research partnerships with grants ranging from 100,000 to 3 million AUD and up to three years in duration. The program aims to improve the competitiveness of domestic industries by involving SMEs and research institutions in collaborative research and promoting high-quality research[53].

Both CRC and CRC-P are under the supervision of the DISR. They have supported 425 initiatives and provided 5.5 billion AUD to date. Initially, the focus of these programs was to support the expansion, competitiveness, and resilient supply chain construction of the domestic manufacturing industry. However, since 2022, the programs have been

52 Australian Government "Funding for medium to long-term, industry-led research collaborations", accessed January 31, 2023. https://business.gov.au/grants-and-programs/cooperative-research-centres-crc-grants

53 Australian Government "Funding for short-term, industry-led research collaborations", accessed January 31, 2023. https://business.gov.au/grants-and-programs/cooperative-research-centres-projects-crcp-grants

applied not only to the manufacturing industry but also to other key sectors such as mining, healthcare, agriculture, and the environment, with more than 2 billion AUD allocated to currently operating programs. The overview of both programs is as follows.

Table 2-24 Overview of CRC and CRC-P

Program Name	CRC: Cooperative Research Centers Programs	CRC-P: Cooperative Research Centers Projects
Funding Agencies	DISR	Same as on left
Purpose	Through long-term industry-led joint research programs, solve identified industry challenges and improve the competitiveness, productivity, and sustainability of domestic industries.	Involve SMEs and university research institutions in joint research to promote high-quality research and enhance the competitiveness of domestic industries.
Program Overview	Supports the strengthening of industry competitiveness and innovation by responding to challenges and needs raised by the industry through joint research and development with universities and research institutions. Supports research for up to 10 years.	Provides grants ranging from 100,000 to 3 million AUD for up to three years for industry-led joint research by SMEs, etc.
Program Features	· Supports joint research for up to 10 years. · There is no fixed upper limit for grants, but the maximum is equal to the cash or in-kind contributions from CRC partners (up to 50% of the grant project costs). · Must involve at least one domestic industry organization and one domestic research institution as partners.	· Supports industry-led joint research for up to three years. · Grants are at least 100,000 AUD, with a maximum of 3 million AUD. · Must involve at least two Australian industry entities (one being an SME) and one research institution as partners.

Source: Created by the author from Australian Government's "Funding for medium to long-term, industry-led research collaborations" and "Funding for short-term, industry-led research collaborations"

Table 2-25 Examples of CRC Projects

Center Name	The Cooperative Research Centre for Honeybee Products (CRCHBP)
Project Duration	July 2017 to June 2022
Representatives and Key Members	Dr. Sharon Purchase and Dr. Don Muir
Target Industry	Food Manufacturing (Honey)
Grant Amount	7 million AUD
Project Overview	CRCHBP, in partnership with industry body B-QUAL Australia, developed a new online honey traceability system. The system not only tracks the origin of honey but also brings many other benefits. It is a secure platform for managing business data and can be used for audits and benchmarks. It also provides insights into resources, such as forest logging and fire conditions, vegetation recovery, etc., and supports the planning of hive placements.
Other	CRCHBP partners further expanded the B-QUAL system by adding new features to examine the chemical properties of honey in detail, enabling them to understand the origins of honey. This allows consumers to confirm that the Australian honey they purchase is always of high quality. It also enables Australian beekeepers to prove the high quality of their honey, providing a competitive edge.

Source: Created by the author from CRCHBP's "Cooperative Research Centre for Honey Bee Products - LEGACY"

(3) Business Research and Innovation Initiative (BRII)

The BRII is a grant aimed at SMEs to develop prototypes for solving challenges proposed by the government. It was introduced in 2016 and is provided by the DISR. The purpose of the BRII is to support the research and development of SMEs, commercialize new products and services, and encourage SMEs to participate in government procurement, thus enabling government agencies to procure innovative solutions from SMEs. To date, five rounds have been conducted, with 23 challenges presented by 16 government agencies. The BRII has supported 81 innovative SMEs, providing more than 110 grants and over 32 million AUD to bring new products and technologies to market[54].

(4) Biomedical Translation Fund (BTF)

The BTF was established in 2015 by the then Department of Health. It is a 500 million AUD investment fund, jointly funded by the government and private companies, with each contributing 250 million AUD. By 2022, 27 investments totaling 306.89 million AUD had been made[55].

It aims to support the commercialization of promising biomedical discoveries and new technologies through investments and bring them to the market.

[54] Australian Government "Business Research and Innovation Initiative", accessed January 31, 2023. https://business.gov.au/grants-and-programs/business-research-and-innovation-initiative

[55] DISR, "ANNUAL REPORT 2021–22", https://www.industry.gov.au/sites/default/files/2022-11/industry-innovation-and-science-australia-annual-report-2021-22.pdf

3 STI Policies of the New and Old Administrations

This section organizes information on Australia's past STI-related policies and those announced by the new administration. The first half discusses the progress of the NISA announced in 2015 and existing STI policies. The second half speculates on the direction of the new STI policies to be announced by September 2023, based on press releases and interviews with STI stakeholders.

3.1 Past STI Policies

A general election was held in Australia in May 2022, with the Labor Party regaining power for the first time in 8 years and 8 months. Anthony Albanese, the leader of the Labor Party, became Prime Minister (Table 3-1).

Table 3-1 Prime Ministers and Their Affiliated Parties

Appointment Date	Prime Minister (honorifics omitted)	Affiliated Party
December 2007	Kevin Michael Rudd	Australian Labor Party
June 2010	Julia Eileen Gillard	
June 2013	Kevin Michael Rudd	
September 2013	Anthony John Abbott	Australian Liberal Party
September 2015	Malcolm Bligh Turnbull	
August 2018	Scott John Morrison	
May 2022	Anthony Norman Albanese	Australian Labor Party

Source: Created by the author based on public information

The core of the current innovation policy is the National Innovation and Science Agenda (NISA) announced during the Malcolm Turnbull administration. There have been other announcements such as the Industry Growth Centres Initiative in 2016, Australia 2030: prosperity through innovation[56] in 2017, the 2020 Technology Investment Roadmap and Modern Manufacturing Strategy during the Scott Morrison administration, but the base is NISA, and all are extensions of it. The main STI policies to date are organized in the following table (Table 3-2).

56 Source: Asia and Pacific Research Center, Japan Science and Technology Agency "2017 Australia 2030: Prosperity through Innovation (tentative translation)"
https://spap.jst.go.jp/resource/pdf/aprc-fy2022-pd-aus06.pdf,
Original link https://www.industry.gov.au/data-and-publications/australia-2030-prosperity-through-innovation

Table 3-2 Main STI Policies in Australia Since 2015

Policy Name	Purpose	Announcement Date	Announcing Agency
National Science Research Priorities (NSRP)	Identifies the government's STI focused investment and support areas for sustainable economic growth, social welfare, and environmental protection.	May 2015	Department of Industry, Innovation and Science (DIIS)
National Innovation and Science Agenda (NISA)	Presents a comprehensive strategy proposing policies and investments to promote innovation, science, research, and education.	December 2015	Prime Minister
Industry Growth Centres Initiative	Presents an industry growth strategy focusing on six competitive sectors in Australia.	October 2016	Department of Industry, Innovation and Science (DIIS)
National Science Statement (NSS: National Science Statement)	Provides a long-term vision for science policy and investment, presenting priorities and directions to strengthen the national research and innovation ecosystem.	March 2017	Department of Industry, Innovation and Science (DIIS)
Australia 2030: prosperity through innovation	Formulates and presents a strategy up to 2030 on optimizing investment in innovation.	November 2017	Innovation and Science Australia (ISA)
2020 Technology Investment Roadmap	Provides a strategic roadmap to promote investment in low-emission and sustainable energy technologies.	May 2020	DCCEEW / DISR
Modern Manufacturing Strategy	Formulates a strategy to reinvigorate Australian manufacturing and enhance competitiveness domestically and internationally.	October 2020	DISR
National Research Infrastructure Roadmap 2021 (NRI)	Presents a 10-year future plan for Australia's research infrastructure.	April 2022	DOE
National Reconstruction Fund (NRF: National Reconstruction Fund)	Presents seven priority areas for supporting the recovery of regions affected by natural disasters or other impacts and economic revitalization.	October 2022	Prime Minister

Source: DIIS, "Industry Growth Centres Initiative: Progress and Impact July 2019", DoE, "2016 NATIONAL RESEARCH INFRASTRUCTURE ROADMAP", "2021 NATIONAL RESEARCH INFRASTRUCTURE ROADMAP", DISR, "Australia's National Science Statement", "National Innovation and Science Agenda report", "Australia 2030: Prosperity through Innovation", "Make it Happen: The Australian Government's Modern Manufacturing Strategy", "TECHNOLOGY INVESTMENT ROADMAP DISCUSSION PAPER" and "National Reconstruction Fund: diversifying and transforming Australia's industry and economy"

3.1.1 National Innovation and Science Agenda (NISA)

The NISA, announced by Prime Minister Turnbull in December 2015, focused on science, research, and innovation as long-term drivers of employment, economic growth, and national prosperity, through four main pillars (principles) aimed at promoting STI in Australia. This section revisits NISA's policy content in light of the current situation in Australia.

(1) Overview of NISA[57]

NISA is based on four pillars, under which policy goals and programs to achieve these goals are set (Table 3-3).

Table 3-3 The Four Pillars of NISA

	Pillar	Overview
1	Culture and Capital	Aim to create a culture of innovation in Australia and improve access to capital for emerging companies and small businesses. This includes initiatives such as tax reform to encourage investment in early-stage companies, and the establishment of entrepreneur programs to provide funding, advice, and support to emerging companies and small businesses. The government provides new tax incentives to eliminate biases against companies that take risks and innovate, co-invests to commercialize promising ideas through the CSIRO Innovation Fund and the Biomedical Translation Fund, and supports the expansion of the private sector.
2	Collaboration	Aim to promote innovation in Australia by facilitating collaboration between industry and researchers. This includes establishing national joint research infrastructure to strengthen industry-researcher collaboration and initiatives like the CSIRO Innovation Fund to support the commercialization of research. The government changed the incentives for funding allocation to ensure that a significant portion of research funds is dedicated to industry collaboration. It is also making long-term investments in world-leading research infrastructure to ensure researchers have access to the necessary infrastructure.
3	Talent and Skills	Aim to develop the skills and talents necessary to support innovation in Australia. This includes initiatives such as establishing new scholarships to encourage students to pursue careers in science, technology, engineering, and mathematics (STEM) fields, and formulating a new Global Innovation Strategy to attract top international talent to Australia. The government ensures students acquire problem-solving and critical reasoning skills. It promotes coding in schools to help students adapt to the digital age. Additionally, the government changed visa systems to connect Australia with other innovative economies and attract more entrepreneurs and researchers from abroad.
4	Government as an Exemplar	Aim for the government itself to set an example and promote innovation. This includes initiatives such as establishing a new Digital Transformation Office to advance the government's digital agenda and implementing new procurement policies to encourage the government to purchase products and services from innovative companies. The government becomes more innovative in service delivery, sets an example, opens up data to the public, and makes it easier for startups and innovative SMEs to provide technology services to the government.

Source: Created by the author from DISR's "National Innovation and Science Agenda report"

[57] Source: Asia and Pacific Research Center, Japan Science and Technology Agency "Tentative translation of National Innovation and Science Agenda report" https://spap.jst.go.jp/resource/pdf/aprc-fy2022-pd-aus01.pdf,
Original link https://www.industry.gov.au/publications/national-innovation-and-science-agenda-report

(2) Initiatives Based on NISA

The major policies and initiatives being undertaken by the government to achieve the four pillars set in NISA in 2015 are organized below (Table 3-4)

Table 3-4 Major Policies and Initiatives

Pillar	Policies and Initiatives	Overview
Culture and Capital	Setting tax incentives	· Strengthening the system that allows reducing taxable income using past losses. · Establishing new rules for venture investments that exempt taxes when investing in innovative companies in the early and growth stages of the startup lifecycle. · Applying preferential tax treatment for early-stage investors, as a tax incentive for investing in emerging companies expected to have high growth (eligible early-stage innovation companies).
	Co-investment initiatives	· The government will provide AUD 70 million over 10 years to the CSIRO-managed Innovation Fund, which funds early-stage commercial research based on excellent science. · The Biomedical Translation Fund will co-invest with private investors at a 50:50 ratio to support fundraising.
Collaboration	Providing research funds through block grants	· Simplifying arrangements for research support to enhance incentives for universities and university researchers to take an interest in business and end-users. · An additional AUD 50 million in funding is provided annually to increase universities' interest in commercialization research, etc.
	Strengthening the ARC Linkage Program	· The ARC will revise the guidance for Linkage Projects to ensure high-quality proposals based on joint partnerships. · Simplifying the application process for the Linkage Program to allow for quick and attractive applications.
Talent and Skills	Promoting coding and computing in schools	· The Council of Australian Governments (COAG) supports a curriculum that includes elements of digital technology, and the government will contribute AUD 3.5 million for coding education.
	Improving the visa system	· Improving the 457s visa to ensure emerging companies can access required workforces in a timely manner. · Introducing a new visa to welcome emerging entrepreneurs. · Utilizing the government's overseas network to actively seek out talented individuals and attract them to Australia. · Supporting permanent residency for postgraduate students with high-quality STEM or ICT knowledge.
Government as an Exemplar	Revised government procurement	· Through the Digital Transformation Office, creating an environment that makes it easier for the government to procure products and services from startups and innovative small and medium-sized enterprises.
	Leveraging open data	· Non-confidential data will be made openly available in a machine-readable and anonymized form through data.gov.au. Creating an environment that enables private companies to use data to develop new innovative products and business models. · Data61, a digital science unit under the CSIRO, will leverage technology to create new industries and transform existing ones. Additionally, Data61 will expand its PhD program that allows students to directly collaborate with the industry to solve problems and develop new products, processes, services, etc.

Source: Same as Table 3-3

(3) Verifying Results

The first pillar, Culture and Capital, aims to create a culture of innovation in Australia and improve access to capital for startups and small and medium-sized enterprises. When examining trends in fundraising for emerging companies in Australia, the number and amount of venture capital investments increased from 167 cases and AUD 900 million in 2015, when NISA was announced, to 267 cases and AUD 7.9 billion in 2021. The increase or decrease in venture investments is caused by various factors, but improvements in the fundraising environment for startups can be inferred (Figure 3-1).

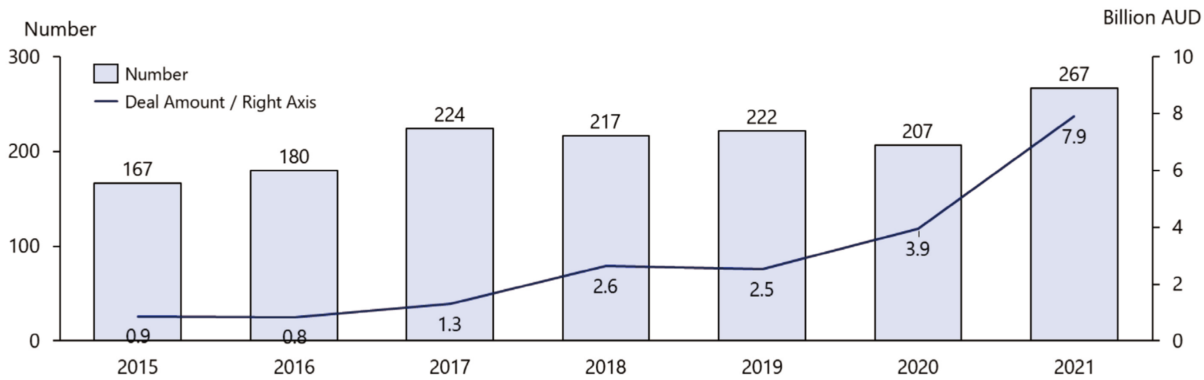


Figure 3-1 Trends in the number and amount of venture investments in Australia

Source: Created by the author from Australian Investment Council's "Year Book 2022"

The second pillar, "Collaboration," aims to promote collaboration between the industrial sector and research institutions, including universities, to boost innovation in Australia. The government's inducement of collaboration through the ARC's Linkage Program and the DISR's CRC has increased, along with the amount of research funds received by universities from the industry. Funds increased from AUD 481 million in 2017 to AUD 666 million in 2021, indicating that research cooperation between universities and the industry is expanding (Figure 3-2).

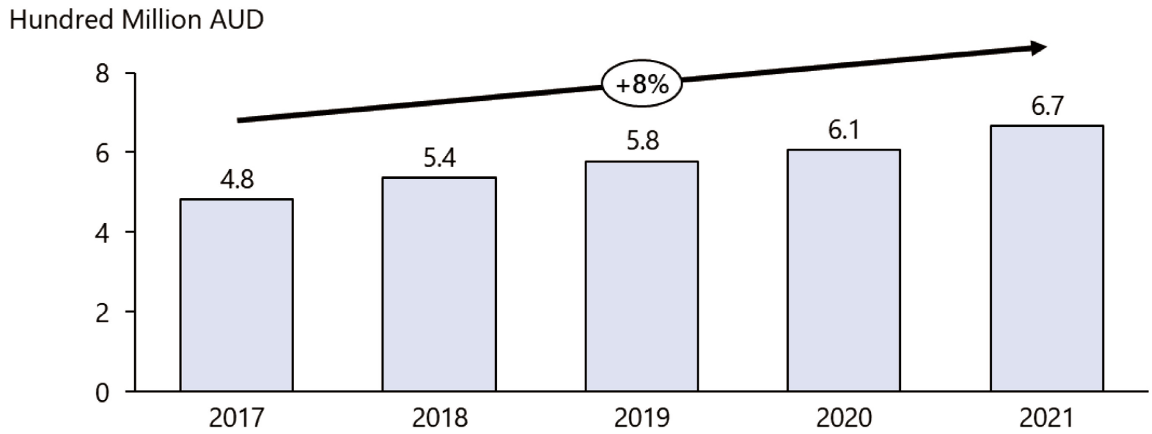


Figure 3-2 Trends in funding flow from the industry to universities

Source: Created by the author from DoE's "Research and Experimental Development, Higher Education Organisations, Australia"

The third pillar, "Talent and Skills," aims to acquire and nurture the talent necessary to support Australia's innovation. The relaxation of VISA authorization for STI-related talents has led to a gradual increase in VISA approvals for professional and scientific and technical job personnel from 2910 in 2015 to 3440 in 2019. However, the number of VISAs granted significantly decreased due to travel restrictions and border closures caused by COVID-19 (Figure 3-3). Australia has also actively accepted students from China and India, but similarly, these numbers have decreased due to COVID-19. A full recovery is expected from 2023 onwards (Figure 3-4).

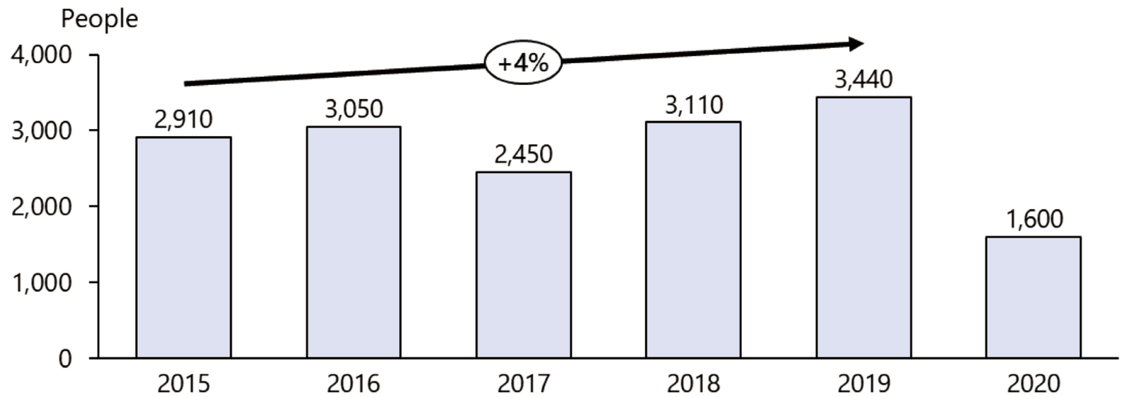


Figure 3-3 Trends in VISA approvals for foreign professionals and scientific and technical jobs

Source: Created by the author from Department of Home Affairs' "Visa statistics"

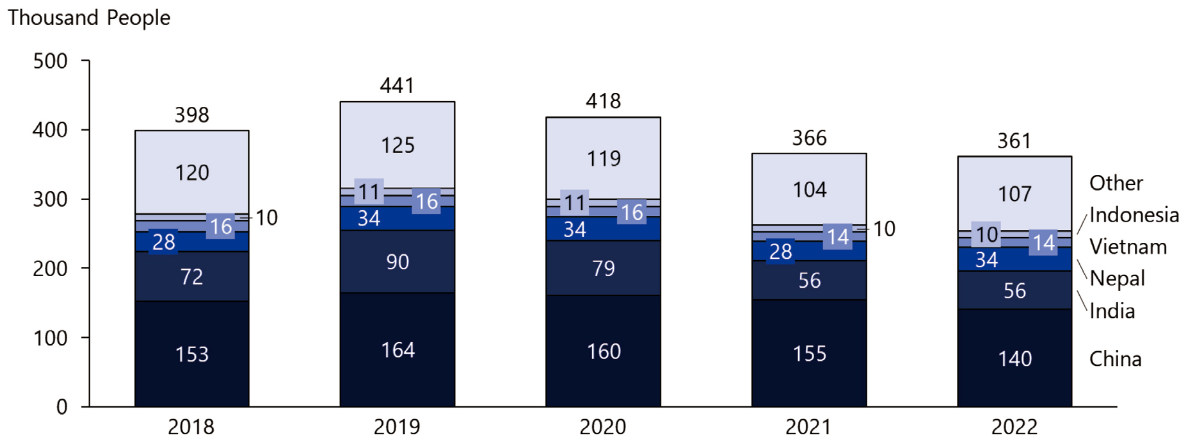


Figure 3-4 Trends in university enrolment numbers by country of origin

Source: Created by the author from DoE's "International Student Data - full year data (based on data finalised in December 2022)"

The fourth pillar, "Government as an Exemplar," aims for the government itself to be an example and promote innovation. Since the announcement of NISA, the Australian government has been advancing the publication of related data and announced an open data policy aimed at accessing government data by the public. This policy requires government agencies to make data available in a machine-readable format wherever possible. Additionally, in 2016, Data.gov.au, a central portal site, was launched, to aggregate government data. This site allows access to over 45,000 datasets provided by more than 500 Australian government agencies. Furthermore, in October 2016, the Digital Transformation Agency (DTA) was established to promote the government's digital transformation. The DTA is working on developing open data standards and guidelines and promoting the use of open data by the government[58].

3.1.2 National Science Research Priorities (NSRP)

The NSRP, announced by the Australian government in 2015, aims to clarify the focus of STI research to address important issues such as sustainable economic growth, social welfare, and environmental protection. The following nine priority areas have been set with the goal of maximizing the country's long-term benefits by guiding the allocation of research and development funds at the national level.

Table 3-5 National Science Research Priorities (NSRP)

	Priority Areas	Major Themes
1	Food	Production, supply, safety, health
2	Land and Water	Land use, agricultural production, water resource management
3	Environmental Change and Biodiversity	Climate change, ecosystem adaptability, biodiversity
4	Energy	Energy supply, storage, efficiency
5	Resources	Exploration, Development, and Utilization of Earth Resources
6	Advanced Manufacturing	Advanced and smart manufacturing, new materials
7	Cybersecurity	Data protection, security measures, privacy
8	Transportation	Efficient and Sustainable Transportation Systems
9	Health	Disease prevention and treatment, health promotion

Source: Created by the author from DISR's "Australia's Science and Research Priorities 2015"

3.1.3 National Science Statement (NSS)

The NSS is a document by the Australian government aimed at realizing the vision of 'enriching Australian society through science.' It sets out medium to long-term goals and principles regarding STI, illustrating the government's role in achieving these goals and adhering to these principles.

The NSS outlines four objectives: (1) engaging all Australians in science, (2) enhancing scientific capabilities and skills, (3) creating new research, knowledge, and technologies, and (4) improving the lives and prosperity of Australians through science and research.

To achieve these objectives, the government's role is described as: (1) directly investing in Australia's future from basic to applied research, providing funds and other resources for critical scientific infrastructure, facilities, and

58 DTA, "About us", Accessed January 31, 2023. https://www.dta.gov.au/about-us

STEM education to support science, (2) participating in science through the creation, use, and sharing of research, data, information, and the operation of scientific research infrastructure, and (3) making science useful through institutional settings that form reciprocal interactions between the science system and businesses or communities, including the conversion of research into economic and other benefits[59].

3.2 The Current Government's STI Policy

In 2022, Minister for Industry and Science, Ed Husic, announced plans to update the NSRP in relation to STI policy. At that time, it was emphasized that the current priorities do not touch upon First Nations' knowledge, climate change issues are not properly recognized, and efforts towards new critical technologies essential for national prosperity are insufficient.

Dr. Cathy Foley, the Chief Scientist, is tasked with leading discussions for the new NSRP and NSS, with support from a task force established within the DISR. Considerations are now underway. These revision efforts include extensive consultations with stakeholders in science, research, and industry, as well as the general public.

The NSRP and NSS under review are expected to be revised in consideration of other government initiatives such as the National Reconstruction Fund (NRF) and others. This review is also expected to complement revisions and initiatives such as the revision of women's programs in STEM fields, support strategies in quantum engineering and robotics, ARC revisions, and the development of inter-university agreements. The new NSRP and NSS are scheduled to be published by September 2023 (Figure 3-5).

Figure 3-5 Review steps and schedule for NSRP and NSS

Source: Created by the author from DISR's "Australia's science and research priorities: conversation starter"

[59] DISR, "Australia's National Science Statement", Accessed January 31, 2023. https://www.industry.gov.au/publications/australias-national-science-statement

3.2.1 Direction of New STI Policy

The direction of the new government's STI policy will not be clear until the new NSRP and NSS announcements. However, Australia has traditionally focused on addressing key issues in its STI policy deliberations. Specifically, it has prioritized fields related to important social challenges, such as the environment and energy, strengths in medical and bio, and resources and agriculture that earn foreign currency and create employment in rural areas. When interviewed, experts familiar with Australia's STI agreed with this understanding, believing that the change of government is unlikely to alter the core of STI policy. While changes in superficial names and priorities, as well as some revisions of priority areas, are possible, many of the existing priorities are likely to continue. As part of these reviews, other government initiatives and important issues posed by various ministries and agencies are also considered, and adjustments and decisions on priority areas are expected to be made in light of the following factors:

Table 3-6 Considerations at the time of reviewing NSRP and NSS

Anticipated perspectives
· Major challenges and opportunities facing Australia · Alignment with government priorities such as the National Reconstruction Fund · Australia's competitive strengths and comparative advantages · Industry intentions, needs, and future investment trends · The necessity for regular review and updates · Further promotion of domestic and international collaboration towards common goals · Removal of barriers to collaboration through the promotion of open access and data sharing · Enhancement of engagement in science and technology strategies involving citizens, research institutions, and industries. Specifically, increasing skilled workers in STEM and enhancing the science and technology sector's response to industrial, social, and economic needs · Establishment of a mechanism for scientific advice to the government by independent experts

Source: Created by the author based on interviews

The setting of priority areas in STI serves to clarify the sectors that the government values, promoting activities and growth in those areas. The 2015 NSRP set nine focus areas, but these are expected to be further narrowed down and reviewed considering statements from Prime Minister Albanese and key ministers: "renewable energy, emission reduction, transition to net-zero, more proactive support for climate change," "utilization of indigenous knowledge in science, technology, and innovation," and "exploration of new technologies and scientific research not only for economic growth but also for national well-being".

When a new policy direction is set by the government, new policies aligned with this direction are also expected to be formulated and existing policies modified by relevant ministries and agencies with high relevance to STI.

4 Sector-Specific STI Policy

4.1 Critical Technologies

In August 2022, the Australian government announced seven critical technologies that will become important for national interest within the next ten years and started considering new initiatives to promote research and development, human resources development, and infrastructure necessary for the advancement of these technologies. The listed technologies are current and future technologies that could significantly impact Australia's national interest (economic prosperity, national security, social cohesion), many of which relate to defense and security, but broader and more applicable technologies are also included. The list is below (Table 4-1). This chapter focuses on each technology, organizing related policies, research and funding trends, and information on strong research institutions and researchers in related fields.

Although the NISA provides national guidelines as part of Australia's STI policy, strategies are created by each ministry, leading to a general direction but also sometimes inconsistencies in priorities between the government and ministries, and between ministries. Critical technologies are managed by the DISR from a national interest perspective, differing from other policy priority areas.

Table 4-1 Critical technologies by field

	Critical Technology Fields	Critical Technology Subsectors
1	Advanced Materials and Manufacturing	Advanced manufacturing (including 3D printing), advanced composite materials, advanced explosives and energy materials, advanced magnets and superconductors, advanced protective features, continuous flow chemical synthesis, coatings, critical mineral extraction and processing, advanced machining processes, nanoscale materials and manufacturing, novel metamaterials, smart materials
2	AI, Computing, and Communication Technologies	Advanced data analysis, advanced integrated circuit design and manufacturing, advanced optical communication, advanced radio frequency communication (including 5G and 6G), artificial intelligence (AI) algorithms and hardware accelerators, distributed ledger, high-performance computing, machine learning, natural language processing (including voice and text recognition & analysis), cybersecurity technologies
3	Biotechnology, Genetic Engineering, and Vaccines	Biological manufacturing, biomaterials, genetic engineering, genome and gene sequencing and analysis, nanobiotechnology, nanoscale robotics, neural engineering, new antibiotics and antiviral drugs, nuclear medicine and radiation therapy, synthetic biology, vaccines and medical countermeasures
4	Energy and Environment	Biofuels, directed energy technologies, batteries, hydrogen and ammonia for power, nuclear energy, management and recycling of nuclear waste, solar power, supercapacitors
5	Quantum	Post-quantum cryptography, quantum communication (including quantum key distribution), quantum computing, quantum sensors
6	Positioning, Navigation, and Timing	Advanced imaging systems, atomic clocks, gravity sensors, inertial navigation systems, magnetic field sensors, miniaturized sensors, multispectral and hyperspectral imaging sensors, optical sensors, radar, satellite positioning and navigation, expandable and sustainable sensor networks, sonar and acoustic sensors
7	Transportation, Robotics, and Space	Advanced aircraft engines (including hypersonic), advanced robotics, autonomous system operation technologies, drones, swarm robotics, collaborative robots, small satellites, space launch systems (including launch vehicles and support infrastructure)

Source: Created by the author from DISR's "List of critical technologies in the national interest"

4.2 Advanced Materials & Manufacturing

Advanced materials and manufacturing utilize cutting-edge materials, processes, and technologies to create high-value added products and services. This field includes 12 subsectors (1) Advanced manufacturing (including 3D printing), (2) Advanced composite materials, (3) Advanced explosives and energy materials, (4) Advanced magnets and superconductors, (5) Advanced protective features, (6) Continuous flow chemical synthesis, (7) Coatings, (8) Critical mineral extraction and processing, (9) Advanced machining processes, (10) Nanoscale materials and manufacturing, (11) Novel metamaterials, (12) Smart materials[60].

60 DISR, "List of critical technologies in the national interest," accessed January 31, 2023. https://www.industry.gov.au/publications/list-critical-technologies-national-interest

In critical technologies, subsectors are identified for early focus, and in the advanced materials & manufacturing field, technologies related to minerals such as (3) Advanced explosives and energy materials, and (8) Critical mineral extraction and processing have been selected.

4.2.1 Related Policies

The DISR announced the “Modern Manufacturing Strategy” in October 2020 to support the advancement of the advanced materials and manufacturing industry, aiming for business expansion amongst manufacturers, enhanced international competitiveness, and job creation. This strategy introduces three strategic elements (Table 4-2):

Table 4-2 Strategic elements of the Modern Manufacturing Strategy

	Strategic Elements & Initiatives	Overview
1	Modern Manufacturing Initiative (MMI)	MMI is an initiative investing 1.3 billion AUD in large-scale transformation projects. It aims to encourage private investment, enhancing the scale, network, and capabilities of domestic manufacturers, and supporting the transformation and growth of value chains. It also provides funding for mega-projects that promote between-industry and industry-academia-government collaboration to build economies of scale.
2	Supply Chain Resilience Initiative	The government has announced a 107.2 million AUD Supply Chain Resilience Initiative. This funding addresses vulnerabilities and challenges in the domestic and international supply chains of critical products.
3	Manufacturing Modernisation Fund (MMF)	As part of the government’s job creation plan, the MMF supports the modernization of the manufacturing industry to revitalize the Australian economy. Specifically, it provides funding for companies to make investments such as equipment upgrades.

Source: Created by the author from DISR’s “Make it Happen: The Australian Government’s Modern Manufacturing Strategy”

4.2.2 Research & Funding Trends

Examining ARC funding achievements reveals that research funding in the advanced manufacturing sector increased from 79.43 million AUD in 2017 to 94.79 million AUD in 2022.

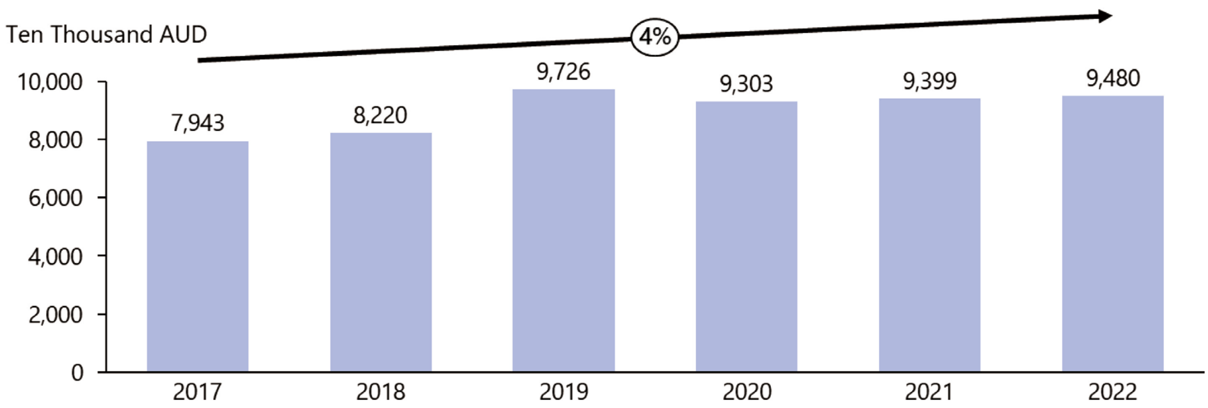


Figure 4-1 ARC's funding achievements for advanced manufacturing

Source: Created by the author from ARC's "The National Competitive Grants Program dataset"

4.2.3 Key Research Institutions, Researchers, and Projects

Referencing The Weekend Australian's "Research 2023: These are the top researchers and institutions in 250 fields of research (Research Magazine 2023)", relevant areas from the 250 fields have been extracted, and key researchers and research institutions are organized in the table below.

Table 4-3 Top Researchers and Research Institutions in Advanced Materials & Manufacturing

Field	Top Researchers	Top Research Institutions
Combustion & Propulsion	Evatt Hawkes, UNSW	University of Queensland
Manufacturing & Mechanical	Ang Liu, UNSW	University of Wollongong
Mechanical Engineering	Jie Yang, RMIT University	RMIT University
Mining & Mineral Resources	Murat Karakus, University of Adelaide	Curtin University
Textile Engineering	Lijing Wang, RMIT University	RMIT University
Ceramic Engineering	Shujun Zhang, University of Wollongong	UNSW
Chemical and Material Science (General)	Shi Zhang Qiao, University of Adelaide	University of Adelaide
Composite Materials	Tuan Ngo, University of Melbourne	University of Melbourne
Material Engineering	Shi Xue Dou, University of Wollongong	UNSW
Nanotechnology	Shi Xue Dou, University of Wollongong	UNSW
Polymers & Plastics	Cyrille Boyer, UNSW	UNSW
Condensed Matter Physics and Semiconductors	Robert Ward, Australian National University	Australian National University

Source: Created by the author from The Weekend Australian's "RESEARCH MAGAZINE 2023: Our top 250:celebrating the best. These are the top researchers and institutions in 250 fields of research"

This section introduces Dr. Shi Xue Dou, a distinguished Professor at the Institute for Superconducting & Electronic Materials, University of Wollongong, as a representative researcher in the field of advanced materials and manufacturing. Dr. Dou has published numerous impactful papers on superconductivity research using nanoparticles, specializing in energy and electronic materials, and has been selected as a highly cited researcher in the field of materials science by Thomson Reuters. In 2003, he was awarded the Australian Centenary Medal by the Prime Minister for his contributions to materials science and engineering, in 2019 he was awarded the Order of Australia for his contributions to superconductivity and electronic materials, in 2020 he was selected as one of the top 5 lifetime achievers in the field of physical sciences by Australian Research Magazine, and in 2021 he received the ICMC Lifetime Achievement Award at the International Cryogenic Materials Conference.

Table 4-4 Overview of Distinguished Professor Shi Xue Dou

Researcher Name	Shi Xue Dou
Member Universities	University of Wollongong
Position	Distinguished Professor at the University of Wollongong (Institute for Superconducting & Electronic Materials)
Specialization	· Material Engineering · Structure & Dynamics of Materials · Nanochemistry · Condensed Matter Physics · Materials Properties
Education	· Completed Ph.D. in high-temperature superconductivity at the University of New South Wales in 1998 · Completed Ph.D. in high-temperature chemistry at Dalhousie University in 1984
Career & Posts	· 2022: Distinguished Professor at the University of Wollongong · 2015: Honorary Distinguished Professor at the University of Wollongong
Key Papers (Citations)	· Enhancement of the critical current density and flux pinning of MgB2 superconductor by nanoparticle SiC doping (747) · Preparation and Electrochemical Properties of SnO2 Nanowires for Application in Lithium - Ion Batteries (738) · Enhancement of the critical current density and flux pinning of MgB2 superconductor by nanoparticle SiC doping (675)
Number of Papers Published	1679
Number of Citations	78,027

Source: Created by the author from the University of Wollongong's "BIO," Research.com and Google Scholar (as of March 3, 2023)

4.3 AI, Computing, and Communication Technologies

AI, computing, and communication, while independent technologies, enable more advanced and extensive processing when combined. This field includes 10 subsectors: (1) Advanced data analysis, (2) Advanced integrated circuit design and manufacturing, (3) Advanced optical communication, (4) Advanced radio frequency communication (including 5G and 6G), (5) Artificial intelligence (AI) algorithms and hardware accelerators, (6) Distributed ledger, (7) High-performance computing, (8) Machine learning, (9) Natural language processing (including voice and text recognition & analysis), (10) Cybersecurity technologies.

Technologies selected for early focus include those related to communication, such as (3) Advanced optical communication, (4) Advanced radio frequency communication. Those related to AI such as (1) Advanced data analysis, (5) Artificial intelligence (AI) algorithms and hardware accelerators, (8) Machine learning, (9) Natural language processing. And finally, those related to cybersecurity such as (10) Cybersecurity technologies, (8) Machine learning.

4.3.1 Related Policies

In its aim to be a global leader in the development and implementation of AI, the government has created "Australia's Artificial Intelligence Action Plan." Based on this plan, the government has invested 470 million AUD in direct support for AI since 2018[61].

The AI Action Plan presents a vision for Australia to become a global leader in trusted, safe, and responsible development and adoption of AI, with four focus areas outlined (Table 4-5).

Table 4-5 Focus Areas of the AI Action Plan

Focus 1	Support the development and adoption of AI technologies that lead to job creation, productivity, and competitiveness improvements.
Focus 2	Create an environment to nurture and attract the world's best AI talents, supporting businesses to access global-level talent and expertise.
Focus 3	Use cutting-edge AI technologies to solve national challenges and support Australians to benefit from AI.
Focus 4	Support the development of technologies that reflect Australian values.

Source: Created by the author from DISR's "Australia's Artificial Intelligence Action Plan (2021)"

Regarding communication, the Australian government is committed to the deployment of 5G and future communication technologies, undertaking initiatives in 5G deployment, 5G innovation, security efforts, and international security initiatives (Table 4-6).

61 DISR, "Australia's Artificial Intelligence Action Plan (2021)", accessed January 31, 2023. https://www.industry.gov.au/publications/australias-artificial-intelligence-action-plan

Table 4-6 Government Commitments and Initiatives in Communication

Deployment of 5G	· Rapid utilization of frequency bands · Active participation in international frequency band negotiations · Streamlining mobile carrier procedures · Review of existing telecommunications regulations
Innovation in 5G	Support for trials and demonstrations of 5G technology through the Australian 5G Innovation Initiative. Providing funding of over 22.1 million AUD for a total of 19 projects in agriculture, construction, manufacturing, transportation, etc.
Security	Establishing regulatory mechanisms to enhance security. The Department of Home Affairs is implementing two projects: · Secure-G: Supports testing of secure 5G connections at test labs · 6G Security & Development Program: Supports foundational research on security requirements for 6G and future connectivity technologies
International Security Initiatives	Sharing of information on supply chain security, legislative changes for critical infrastructure, and other domestic and international telecommunications security priorities through international discussions such as QUAD, the Prague 5G Security Conference, and the Five Country Ministerial Communique.

Source: Created by the author from DISR's "ACTION PLAN FOR CRITICAL TECHNOLOGIES[62]"

4.3.2 Research & Funding Trends

Examining ARC funding achievements reveals that research funding in the AI, computing, and communication sector increased from 27.8 million AUD in 2017 to 40.4 million AUD in 2022.

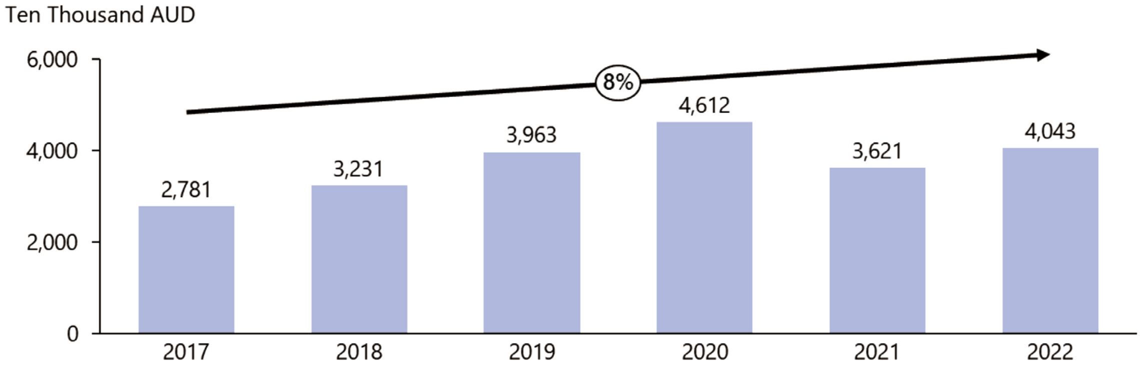


Figure 4-2 ARC's funding Achievements in AI, Computing, and the Communication Sector

Source: Same as Figure 4-1

4.3.3 Key Research Institutions, Researchers, and Projects

Referencing Research Magazine 2023, relevant areas from the listed fields were extracted, and key researchers and

62 https://www.industry.gov.au/publications/action-plan-critical-technologies

research institutions organized in the table below. Notably, Monash University and the University of Technology Sydney each cover four areas, while the University of Melbourne covers three areas.

Table 4-7 Top Researchers and Research Institutions in AI, Computing, and Communication Technologies

Field	Top Researchers	Top Research Institutions
AI	Seyedali Mirjalili, Torrens University Australia	University of Technology Sydney
Computational Linguistics	Robert Dale, Language Technology Group	Macquarie University
Computer Graphics	Maxime Cordeil, University of Queensland	Monash University
Computer Hardware Design	Xinghuo Yu, RMIT University	RMIT University
Computer Networks and Wireless Communication	Derrick Wing Kwan Ng, UNSW	UNSW
Computer Security and Cryptography	Willy Susilo, University of Wollongong	University of Wollongong
Computer Vision and Pattern Recognition	Dacheng Tao, University of Sydney	University of Sydney
Computing Systems	Rajkumar Buyya, University of Melbourne	Swinburne University of Technology
Data Mining and Analysis	François Petitjean, Australian Taxation Office	University of Technology Sydney
Database and Information Systems	Chengqi Zhang, University of Technology Sydney	University of Technology Sydney
Fuzzy Systems	Seyedali Mirjalili, Torrens University Australia	University of Technology Sydney
Human-Computer Interaction (HCI)	Daniel Johnson, Queensland University of Technology	University of Melbourne
Software Systems	Rajkumar Buyya, University of Melbourne	University of Melbourne
Theoretical Computer Science	Serge Gaspers, UNSW	Monash University
Algebra	Aidan Sims, University of Wollongong	University of Melbourne
Engineering & Computer Science (General)	Qing-Long Han, Swinburne University of Technology	UNSW
Automation and Control Theory	Peng Shi, University of Adelaide	Swinburne University of Technology
Physics & Mathematics (General)	Tony Murphy, CSIRO	Monash University
Probability & Statistics and Applications	Daniel Simpson, Monash University	Monash University
Pure and Applied Mathematics	David Wood, Monash University	Curtin University

Source: Same as Table 4-3

This section introduces Professor Rajkumar Buyya from the University of Melbourne as a representative researcher in the field of AI, computing, and communication technologies. Dr. Buyya is one of the most cited researchers in the fields of computer science and software engineering worldwide, selected as a highly cited researcher by Thomson Reuters. In 2015, he received the Mahatma Gandhi Award in recognition of his outstanding contributions to information technology and promoting international cooperation with India, in 2017, he was awarded the Scopus Researcher of the Year by Elsevier's Excellence in Innovative Research Award, and in 2021, he received the Lifetime Achiever and Superstar of Australia Research by The Australian Research Review.

Table 4-8 Overview of Distinguished Professor Rajkumar Buyya

Researcher Name	Rajkumar Buyya
Member Universities	University of Melbourne
Position	Redmond Barry Distinguished Professor, University of Melbourne Director of the Distributed Systems and Cloud Computing Laboratory
Specialization	· Operating Systems · Internet · Cloud Computing
Education	· Completed Ph.D. in Computer Science and Software Engineering at Monash University
Career & Posts	· 2017: Redmond Barry Distinguished Professor, University of Melbourne · 2010: Professor, University of Melbourne
Key Papers (Citations)	· Internet of Things (IoT): A vision, architectural elements, and future directions (6583) · Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility (4663) · CloudSim: a toolkit for modeling and simulation of cloud computing environments and evaluation of resource provisioning algorithms (3363)
Number of Papers Published	1021
Number of Citations	134,166

Source: Created by the author from University of Melbourne's "Prof Rajkumar Buyya," Research.com and Google Scholar (as of March 3, 2023)

4.4 Biotechnology, Genetic Engineering, and Vaccine Fields

Biotechnology, genetic engineering, and vaccines are areas of particular strength for Australia in the field of medicine. This field has 11 sub-sectors: (1) biological manufacturing, (2) biomaterials, (3) genetic engineering, (4) genome and gene sequencing and analysis, (5) nanobiotechnology, (6) nanoscale robotics, (7) neural engineering, (8) new antibiotics and antivirals, (9) nuclear medicine and radiation therapy, (10) synthetic biology, (11) vaccines and medical countermeasures.

Technologies to focus on in the initial stage include those related to genomics and genetic engineering, such as (3) genetic engineering, (4) genome and gene sequencing and analysis (next-generation sequencers), (10) synthetic biology, and those related to novel antibiotics, antivirals, and vaccines, such as (8) new antibiotics and antivirals, (11) vaccines and medical countermeasures.

4.4.1 Related Policies

The Australian Government launched the Medical Research Future Fund (MRFF) in 2015 to support the spread of biotechnology, genetic technology, and vaccines, and encourage investment in key medical technologies. It then expanded it to 20 billion AUD by 2020. Currently, many projects receiving funding are related to technologies such as biological manufacturing, biomaterials, genetic engineering, next-generation sequencers, nanobiotechnology, nanoscale robotics, and neural engineering. Examples of projects funded by the MRFF include those below.

Table 4-9 Examples of Projects Funded by MRFF

Projects	Overview
Zero Childhood Cancer personalized Medicine Program (ZERO)	A world-leading personalized medical trial for high-risk cancer patients under 21, identifying genetic factors of each cancer to customize treatment methods that increase survival rates while minimizing side effects. The initial results (October 2020) showed that 70% of children who received the recommended personalized treatment had positive outcomes (tumor growth stopped, shrank, or completely regressed). Currently, over 500 children are enrolled, with plans to include all children with pediatric cancer in Australia by the end of 2023.
Treatment for Muscle Damage and Wasting Diseases	Muscle stem cells were used to activate the body's muscle stem cells and identify new functions of molecules to repair damage and diseases. This could change the treatment options for thousands of Australians with muscle damage and wasting diseases.

Source: Created by the author from DHAC's "Getting rid of childhood brain cancer" and "World-first discovery promises new therapy for injured or wasted muscle"

4.4.2 Research & Funding Trends

Examining the ARC's funding achievements reveals that research funding in the fields of biotechnology, genetic engineering, and vaccines increased from 115.4 million AUD in 2017 to 127.6 million AUD in 2022. Note that these figures are from the ARC, but competitive funding for pharmaceuticals is primarily provided by the NHMRC, so it is important to be aware that there is a separate funding pool for this research.

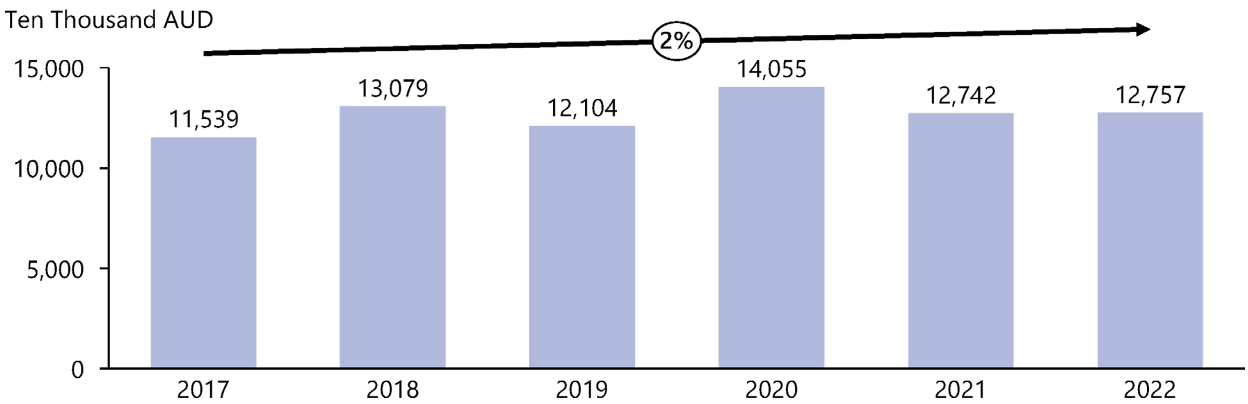


Figure 4-3 ARC's Funding Achievements in the Fields of Biotechnology, Genetic Engineering, and Vaccines

Source: Same as Figure 4-1

4.4.3 Key Research Institutions, Researchers, and Projects

Referencing Research Magazine 2023, relevant areas from the listed fields were extracted, and key researchers and research institutions were organized in the table below. Notably, Monash University and the University of Queensland each dominate four areas.

Table 4-10 Top Researchers and Research Institutions in the Fields of Biotechnology, Genetic Engineering, and Vaccines

Field	Top Researchers	Top Research Institutions
Bioinformatics and Computational Biology	Geoff Webb, Monash University	Monash University
Biomedical Technology	Cuie Wen, RMIT University	University of Queensland
Biotechnology	Philip Hugenholtz, University of Queensland	University of Queensland
Evolutionary Computation	Seyedali Mirjalili, Torrens University Australia	Deakin University
Medical Informatics	Anthony Smith, University of Queensland	University of Queensland
Biochemistry	Michael Jennings, Griffith University	Monash University
Genetics and Genomics	Peter Visscher, University of Queensland	University of Queensland
Gerontology and Geriatric Medicine	Christopher Rowe, Austin Health	University of Sydney
Immunology	Robyn O'Hehir, Monash University	Monash University
Molecular Biology	Edward Holmes, University of Sydney	Monash University

Source: Same as Table 4-3

This section introduces Dr. Peter Visscher from the University of Queensland as a representative researcher in the fields of biotechnology, genetic engineering, and vaccines. Dr. Visscher is a quantitative geneticist studying the variation of traits in populations and has contributed to the development and application of statistical analysis methods for DNA. He was elected an ARC Fellow and a Fellow of the Royal Society in 2018 and was awarded a lifetime honor by the European Molecular Biology Organization in 2020.

Table 4-11 Overview of Professor Peter Visscher

Researcher Name	Peter Visscher
Member Universities	University of Queensland
Position	Professor of Quantitative Genetics, University of Queensland (affiliated with the Institute for Molecular Bioscience)
Specialization	· Genes & Genetics · Statistics
Education	· Completed Ph.D. in Animal Genetics at the University of Edinburgh in 1991 · Completed Master's in Animal Breeding at the University of Edinburgh in 1988
Key Papers (Citations)	· Finding the missing heritability of complex diseases (9097) · Biological insights from 108 schizophrenia-associated genetic loci (6772) · GCTA: a tool for genome-wide complex trait analysis (5920)
Career & Posts	Professor of Quantitative Genetics at the University of Queensland since 2011
Number of Papers Published	997
Number of Citations	147,367

Source: Created by the author from University of Queensland's "Professor Peter Visscher", Research.com and Google Scholar (as of March 3, 2023)

4.5 Energy & Environment Field

Australia, a country rich in resources, is an exporter of coal and natural gas. However, it is also actively promoting the use of renewable energy and the adoption of energy-saving policies, with Prime Minister Albanese recognizing the utilization of renewable energy and the transition to net-zero as important policy issues. This field has 8 sub-sectors: (1) biofuels, (2) directed energy technology, (3) batteries, (4) hydrogen and ammonia for power, (5) nuclear energy, (6) management and recycling of nuclear waste, (7) solar power, (8) supercapacitors.

Technologies to focus on in the initial stage include those related to low-emission gas alternative fuels, with (1) biofuels, (4) hydrogen and ammonia for power being selected.

4.5.1 Related Policies

The Australian Government has launched various measures to promote the energy and environment sector, including the Australian Future Fuels Fund and the National Hydrogen Strategy.

(1) Australian Future Fuels Fund

The Australian Future Fuels Fund, managed by ARENA, aims to address challenges hindering the dissemination of new automotive technologies. For example, it invests in major EV charging networks across Australia.

Initially announced in 2020, the fund was 71.9 million AUD to support the development of public charging infrastructure for electric vehicles and technologies such as hydrogen and biofuels. However, the Australian Government increased the fund by 177.7 million AUD in 2021, planning to expand it to nearly 250 million AUD in total to promote domestic infrastructure development[63].

(2) National Hydrogen Strategy

The DCCEEW announced the National Hydrogen Strategy in 2019, aiming to accelerate the growth of the hydrogen industry through large-scale production and export, among other means. More than 1.2 billion AUD has been invested so far, with additional billions of AUD allocated to related clean energy technologies and manufacturing & infrastructure support. Investment in Australia's hydrogen industry is expected to create over 8,000 jobs in rural areas by 2050 and contribute over 11 billion AUD annually to the GDP[64].

Table 4-12 Main Actions Based on the National Hydrogen Strategy

Hydrogen Funding Program	Provides 464 million AUD to launch clean hydrogen industry hubs to revitalize regional hydrogen industries.
Carbon Capture & Storage (CCS) and Carbon Capture, Utilization & Storage (CCUS) Projects	Over 300 million AUD in development support invested.
Hydrogen Electrolyzer Projects	Through ARENA, provides over 100 million AUD to three 10MW hydrogen electrolyzer projects.
Research, Development & Demonstration Support	Provides over 300 million AUD through CEFC.

Source: Created by the author from DCCEEW's "AUSTRALIA'S NATIONAL HYDROGEN STRATEGY (2019)"

4.5.2 Research & Funding Trends

Examining ARC funding achievements reveals that research funding in the energy and environment field increased from 16 million AUD in 2017 to 18.1 million AUD in 2022, showing a trend of fluctuation but overall increase.

63 Australian Government "Driving consumer choice and uptake of low-emissions vehicles", accessed January 31, 2023. https://www.minister.industry.gov.au/ministers/taylor/media-releases/driving-consumer-choice-and-uptake-low-emissions-vehicles

64 DCCEEW, "AUSTRALIA'S NATIONAL HYDROGEN STRATEGY (2019)" https://www.dcceew.gov.au/sites/default/files/documents/australias-national-hydrogen-strategy.pdf

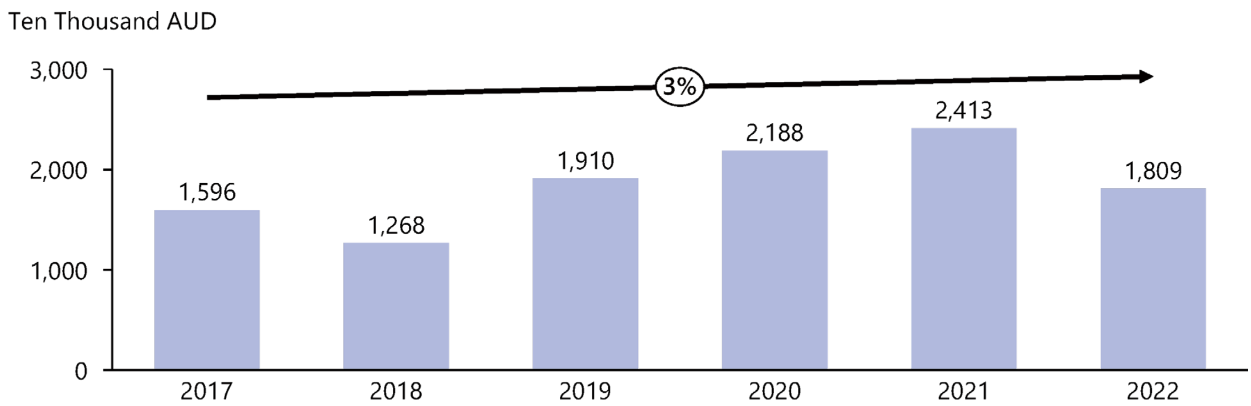


Figure 4-4 ARC's Funding Achievements in the Energy & Environment Field

Source: Same as Figure 4-1

4.5.3 Key Research Institutions, Researchers, and Projects

Referencing Research Magazine 2023, relevant areas from the listed fields were extracted, and key researchers and research institutions were organized in the table below. Notably, the University of New South Wales dominates three areas, while Australian National University and Curtin University each dominate two areas.

Table 4-13 Top Researchers and Research Institutions in the Energy & Environment Field

Field	Top Researchers	Top Research Institutions
Environmental & Geological Engineering	Md Rabiul Awual, Curtin University	Curtin University
Ocean Engineering	Dong-Sheng Jeng, Griffith University	University of Tasmania
Plasma & Nuclear Fusion	Boyd Blackwell, Australian National University	Australian National University
Electrical Engineering	Yam Siwakoti, University of Technology Sydney	UNSW
Sustainable Energy	Martin Green, UNSW	UNSW
Petroleum & Natural Gas	Reza Rezaee, Curtin University	Curtin University
High Energy & Nuclear Physics	Robert Ward, Australian National University	University of Sydney
Water Supply and Treatment	Qilin Wang, University of Technology Sydney	University of Queensland
Electrochemistry	Shi Xue Dou, University of Wollongong	UNSW
Electromagnetism	Yingjie Jay Guo, University of Technology Sydney	University of Technology Sydney
Geophysics	Dietmar Müller, University of Sydney	Australian National University
Thermal Science	Jiyuan Tu, RMIT University	University of Adelaide

Source: Same as Table 4-3

This section introduces Dr. Martin Green from UNSW as a representative researcher in the energy & environment field. Professor Green is recognized as a world-leading researcher for his significant contributions to the development of high-efficiency silicon solar cell devices and the advancement of solar power generation, receiving the Australia Prize in 1999, the Right Livelihood Award in 2002, the Global Energy Prize in 2018, and the Japan Prize in 2021.

Table 4-14 Overview of Professor Martin Green

Researcher Name	Martin Green
Member Universities	University of New South Wales
Position	UNSW Scientia Professor Director of the Australian Centre for Advanced Photovoltaics
Specialization	· Semiconductor Devices · Solar Power Generation · Solar Cell Module Design · Electrical Energy Storage
Education	· Completed Ph.D. at McMaster University (Canada) · Graduated from the University of Queensland
Key Papers (Citations)	· Solar cell efficiency tables (version 57) (13,592) · The emergence of perovskite solar cells (6185) · Solar cells: operating principles, technology, and system applications (3986)
Career & Posts	Founded the Solar Cell Group at UNSW in 1974
Number of Papers Published	945
Number of Citations	110,325

Source: Created by the author from UNSW's "Scientia Professor Martin Green", Research.com and Google Scholar (as of March 3, 2023)

4.6 Quantum Field

Quantum computing utilizes quantum mechanics to perform advanced calculations that are impossible for traditional computers. However, it is still a developing technology with technical challenges and limitations. This field has 4 sub-sectors: (1) post-quantum cryptography, (2) quantum communication (including quantum key distribution), (3) quantum computing, (4) quantum sensors.

All sub-sectors have been selected as technologies to focus on from the initial stage.

4.6.1 Related Policies

To promote the quantum field, the Australian Government developed the National Quantum Strategy in 2019, organizing efforts and support for Australia to become a global leader in quantum technologies[65]. Specifically, the strategy considers strengthening research and development support, promoting commercialization, advancing international partnerships, and developing and training talent. Based on this strategy, initiatives such as the launch of quantum commercialization hubs and the establishment of COEs in India are being promoted.

(1) Quantum Commercialization Hub

The development, commercialization, and adoption of quantum technologies are expected to create 4 billion AUD in economic value and 16,000 new jobs in Australia by 2040. Quantum technology will be key to Australia's future defense and national security capabilities, essential for protecting the public and private sectors from sophisticated cyber attacks. Therefore, the government aims to collaborate with like-minded countries to support the commercialization of Australian quantum research, concentrate on areas where Australia has a comparative advantage, build international supply chains, and establish quantum commercialization hubs.

(2) Australia-India Centre of Excellence (Australia-India COE)

This COE, established in India, supports resilience, competitiveness, reliability, and diverse technological innovations in the region, based on collaboration with Australia as a trusted partner[66]. The following initiatives are being undertaken through the COE.

1. A strengthened partnership with India, the world's second-largest internet market and country with strengths in critical technology policies.
2. Based on shared values, form technology governance in an open, inclusive, and resilient Indo-Pacific.
3. Mitigate delays in the development of policies and regulations for new and emerging technologies.
4. Promote investment opportunities and innovations in technology between Australia and India.
5. Serve as a prototype for a broader Indo-Pacific critical technology network.

4.6.2 Research & Funding Trends

Examining the ARC's funding achievements reveals that research funding in quantum technology has slightly decreased from 7.6 million AUD in 2017 to 6.4 million AUD in 2022. However, since quantum technology is a focus area for the government, a decrease is unlikely, and the possibility of utilizing funds other than the ARC is likely.

65 DISR, "National Quantum Strategy (2019)", https://www.industry.gov.au/publications/national-quantum-strategy

66 Australian Government "Strengthening our technology partnership with India (November 17, 2021)", https://www.foreignminister.gov.au/minister/marise-payne/media-release/strengthening-our-technology-partnership-india

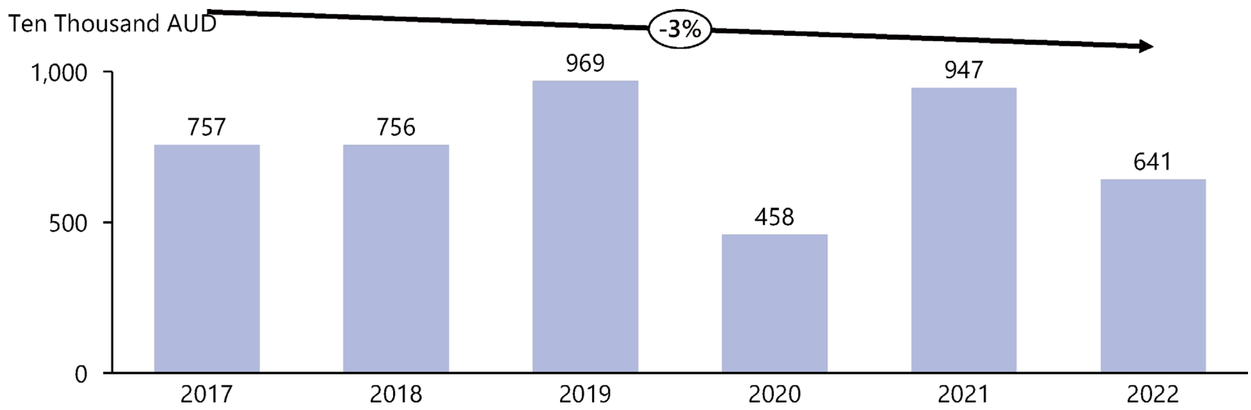


Figure 4-5 ARC's Funding Achievements in Quantum Technology

Source: Same as Figure 4-1

4.7 PNT (Positioning, Navigation, and Timing) Field

In positioning, navigation, and timing, there are 12 sub-sectors: (1) advanced imaging systems, (2) atomic clocks, (3) gravity sensors, (4) inertial navigation systems, (5) magnetic field sensors, (6) miniaturized sensors, (7) multispectral and hyperspectral imaging sensors, (8) optical sensors, (9) radar, (10) satellite positioning and navigation, (11) scalable and sustainable sensor networks, (12) sonar and acoustic sensors. This field features many interdisciplinary technologies and a wide range of related academic fields.

No technologies have been designated for focus at the initial stage in this field.

4.7.1 Related Policies

Positioning, Navigation, and Timing (PNT) are technologies used in various domains and industries, including military and space, and are vital for Australia. The Australian Government, in the August 2022 edition of Positioning News, indicated that it would publish a national PNT roadmap by the end of 2022;[67] however, as of March 2023, such information is not available.

In individual programs, the Australian Government invested AUD 224.9 million in 2018 into the Positioning Australia Program to improve positioning accuracy from 5-10 meters to the 10-centimeter level and accelerate the adoption and development of positioning technology and applications. Related to this program, funds have been allocated for the upgrade of the national Global Navigation Satellite System (GNSS) and ground network to provide high-quality positioning corrections across the country. Efforts are also being made to enhance the accuracy and reliability of positioning by delivering correction signals using the Satellite-Based Augmentation System (SBAS).

PNT is also utilized for military troop coordination, logistics, defense asset management, and precision-guided weapons, among others, making it crucial to ensure reliable PNT functionality under all circumstances. Due to this need for reliability, Quantum-Assured PNT has been selected as a project under DSTG's STaR Shots. The project overview is as follows.

67 Australian Government "Positioning News - August 2022," https://communication.ga.gov.au/pub/pubType/EO/pubID/zzzz62e08e41092c1848/interface.html

Table 4-15 STaR Shots Overview of the Quantum-Assured PNT Project

Background	GPS has had a revolutionary impact on military activities, but the current reliance on GNSS carries significant vulnerabilities, necessitating a positioning, navigation, and timing function that is reliable and always connected. Solutions utilizing new quantum technologies that provide sensitivity, accuracy, and precision even in environments without GNSS signals are needed.
Purpose	The ADF and its partners are working to ensure that positioning, navigation, and timing information is always accessible and operational, even in complex and challenging environments.
Opportunities	· Development, miniaturization, and maturation of quantum clocks, accelerometers, magnetometers, and gravimeters · Advancements in conventional technologies to improve sensitivity, precision, and reduce long-term drift · Integration and fusion of quantum and conventional sensors for improved accuracy

Source: Created by the author from DoD's "Quantum-assured position, navigation and timing"

4.7.2 Research & Funding Trends

Examining the ARC funding achievements reveals that research funding in this field increased from AUD 1.8 million in 2017 to AUD 2.2 million in 2022. However, due to the nature of the technology, some projects may not be fully covered.

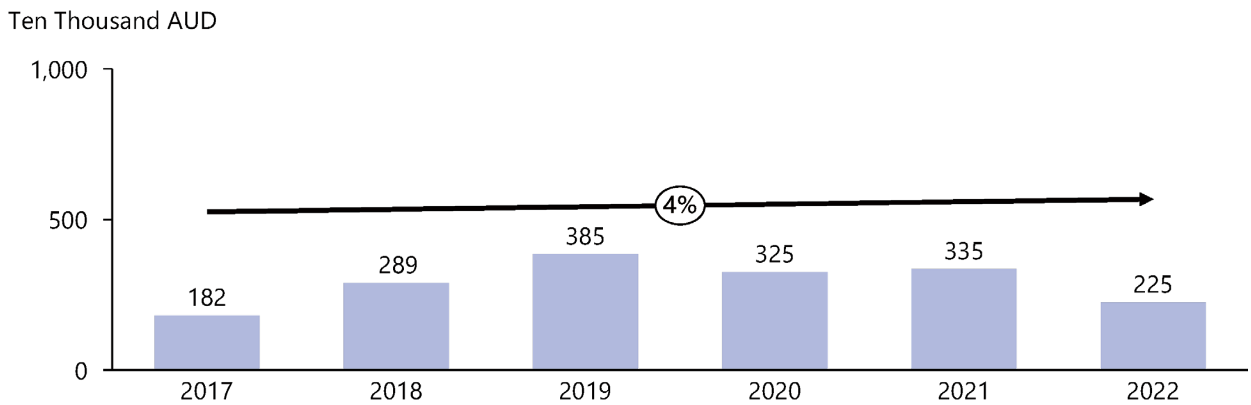


Figure 4-6 ARC's Funding Achievements in the Field of Positioning, Navigation, and Timing

Source: Same as Figure 4-1

4.7.3 Key Research Institutions, Researchers, and Projects

Referencing Research Magazine 2023, relevant areas from the 250 listed fields were extracted, and key researchers and research institutions were organized in the table below.

Table 4-16 Top Researchers and Research Institutions in the Field of Positioning, Navigation, and Timing

Field	Top Researchers	Top Research Institutions
Optics and Photonics	Yuri Kivshar, Australian National University	Australian National University
Radar, Positioning, Navigation	Jinling Wang, UNSW	UNSW
Remote Sensing	Jeffrey Walker, Monash University	University of Queensland
Signal Processing	Yonghui Li, University of Sydney	University of Sydney

Source: Same as Table 4-3

This section introduces Professor Yuri Kivshar from the Australian National University as a representative researcher in the field of positioning, navigation, and timing. The professor has contributed to technological innovation in the field of optics and photonics through research on spatial solitons and nonlinear optics and is recognized as a leading researcher in the country. In 2007, he was awarded the Lyle Medal, the highest award of the Australian Academy of Science, received the State Prize of Ukraine in 2013, the Lebedev Medal (Russia) in 2014, the Humboldt Research Award (Germany) in 2017, and the Max Born Award from the international photonics organization Optica in 2022.

Table 4-17 Overview of Professor Yuri Kivshar

Researcher Name	Yuri Kivshar
Member Universities	Australian National University
Position	Director of the Non-Linear Physics Centre, Research School of Physics, Australian National University
Specialization	· Quantum Mechanics · Optical Systems · Photons
Education	· Earned a Ph.D. in Physics and Mathematics from the National University of Kharkiv, Ukraine · Completed a master's degree in physics at the National University of Kharkiv, Ukraine
Career & Posts	· Currently, Director of the Non-Linear Physics Centre, Research School of Physics, Australian National University · 2002 Deputy Director of the ARC Centre of Excellence for Ultrahigh-bandwidth Devices for Optical Systems (CUDOS)
Key Papers (Citations)	· Optical Solitons: From Fibers to Photonic Crystals (2089) · Fano resonances in nanoscale structures (1874) · Optically resonant dielectric nanostructures (1221)
Number of Papers Published	595
Number of Citations	99,989

Source: Created by the author from Australian National University's "Professor Yuri Kivshar" Research.com and Google Scholar (as of March 3, 2023)

4.8 Transport, Robotics, Space

Transport, robotics, and space are areas requiring advanced engineering and technology, and are used in transportation, communication, surveillance, exploration, and the military, among others. The field is divided into six sub-sectors: (1) advanced aircraft engines (including hypersonic), (2) advanced robotics, (3) autonomous system operation technologies, (4) drones, swarm robots, collaborative robots, (5) small satellites, and (6) space launch systems (including launch vehicles and support infrastructure).

Initial technologies of focus include autonomous vehicles, drones, and robotics, with (2) advanced robotics, (3) autonomous system operation technologies, and (4) drones, swarm robots, and collaborative robots being selected from the sub-sectors.

4.8.1 Related Policies

Transport, robotics, and space are broad and deep fields, but focusing on space, the Australian Government established the Australian Space Agency in 2018 to promote the space industry, develop space technologies and services, engage in international cooperation, and for policy-making, and regulatory purposes. In 2019 the agency formulated The Australian Civil Space Strategy 2019-28 as its strategy for the next decade[68]. It aims to expand the currently AUD 3.9 billion space industry to AUD 12 billion by 2030, creating an additional 20,000 jobs. To realize this strategy, the Australian Government has invested over AUD 700 million in this field since 2018. The Australian Government has also created technology roadmaps for each of the six priority areas listed in the table below, many of which are critical technologies and related areas.

Table 4-18 Six Priority Technologies Based on the Space Strategy

Communication Technologies and Services	Satellite communication enables communication in places where regular radio communication is not available and is essential for communication with ships at sea, for example.
Earth Observation	The capture of images from space through satellites can be used for various purposes such as monitoring wildfires, water resources, and farmland.
Space Situational Awareness	Space Situational Awareness (SSA) involves collecting and analyzing information on the position, velocity, and orbit of man-made objects in Earth orbit and celestial objects in space to monitor satellites and space debris and is an essential part of space traffic management.
Remote Operation and Robotics	Australia leads the world in remote operation of equipment in industries such as mining, oil, and gas, and this capability could potentially be used in space exploration.
Positioning, Navigation, and Timing Technologies	Utilization of satellites for positioning, navigation, and timing is essential for accurate location and time information, and is expected to be used in financial institutions, civil aviation, and shipping.
Access to Space	Access to space refers to the capability to launch satellites into space.

Source: Created by the author from Australian Space Agency's "Advancing Space Australian Civil Space Strategy 2019- 2028"

68 DISR, "Australian Civil Space Strategy 2019 - 2028," accessed on January 31, 2023. https://www.industry.gov.au/publications/australian-civil-space-strategy-2019-2028

4.8.2 Research & Funding Trends

Reviewing the Australian Research Council's (ARC) funding achievements in the field of transport, robotics, and space reveals a significant investment of AUD 111.69 million was made in 2017 due to the formation of three Centres of Excellence (COEs) each worth around AUD 30 million. Though there was a slight decrease from 2018 to 2020, funding has been on the rise again since 2021.

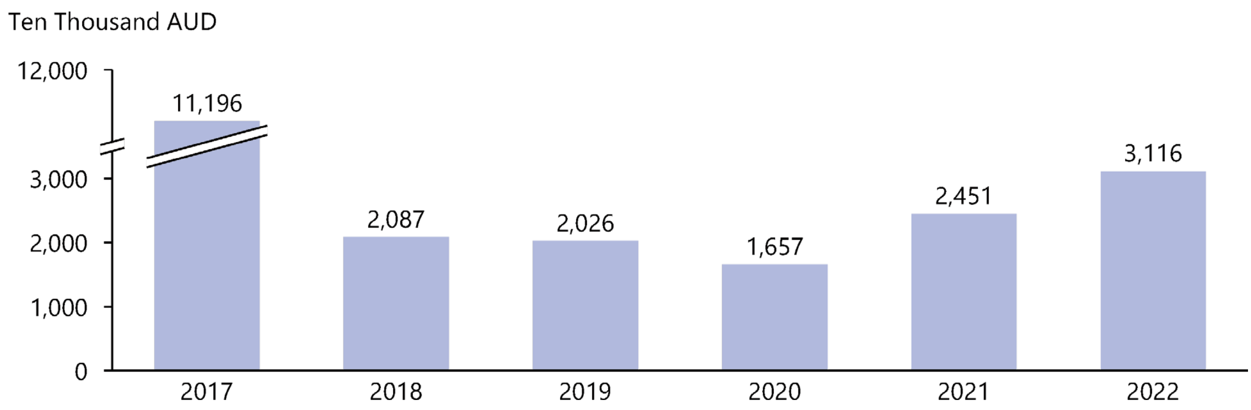


Figure 4-7 ARC's Funding Achievements in Transport, Robotics, and Space

Source: Same as Figure 4-1

4.8.3 Key Research Institutions, Researchers, and Projects

Referencing Research Magazine 2023, relevant areas from the 250 listed fields were extracted, and key researchers and research institutions were organized in the table below.

Table 4-19 Top Researchers and Research Institutions in the Field of Transport, Robotics, and Space

Field	Top Researchers	Top Research Institutions
Robotics Engineering	Inkyu Sa, CSIRO	Queensland University of Technology
Electromagnetism	Yingjie Jay Guo, University of Technology Sydney	University of Technology Sydney
Astronomy & Astrophysics	Richard McDermid, Macquarie University	Australian National University
Spectroscopy and Molecular Physics	Kamila Kochan, Monash University	University of Queensland
Aeronautical and Aerospace Engineering	Michael Smart, University of Queensland	RMIT University

Source: Same as Table 4-3

Though not included in the above table, this section introduces Distinguished Professor Karu Esselle from the University of Technology Sydney as a representative researcher in the field of transport, robotics, and space. The professor is a researcher in the fields of electromagnetic engineering and antenna engineering, utilized in communications, defense, and space technology, and is recognized domestically as a leading researcher in both microelectronics and electromagnetic engineering. He has received numerous awards as a researcher, including the most prestigious space award in the country in 2022. In 2021, he also received the Academic of the Year Award and the Defence Connect Excellence Award at the Australian Defence Industry Awards in 2021.

Table 4-20 Overview of Professor Karu Esselle

Researcher Name	Karu Esselle
Member Universities	University of Technology Sydney
Position	Distinguished Professor School of Electrical and Data Engineering, University of Technology Sydney Visiting Professor at the Faculty of Science and Engineering, Macquarie University
Specialization	· Antenna Engineering · Electromagnetic Engineering · Microelectronics
Education	· Completed a master's and Ph.D. in Applied Science at the University of Ottawa, Canada · Graduated from the Faculty of Engineering, University of Moratuwa, Sri Lanka
Career & Posts	· Currently, Distinguished Professor in Electromagnetic and Antenna Engineering, School of Electrical and Data Engineering, University of Technology Sydney · 2019 Visiting Professor at the Faculty of Science and Engineering, Macquarie University · 2016 Director of WiMed Research Centre, Macquarie University
Key Papers (Citations)	· Dielectric resonator antennas (1376) · Advanced millimeter-wave technologies: antennas, packaging and circuits (422) · Printed antennas for wireless communications (308)
Number of Papers Published	666
Number of Citations	13,947

Source: Created by the author from University of Technology Sydney's "BIO", Research.com and Research.com (as of March 3, 2023)

5 International collaboration

This chapter aims to assess the relationship between Australia and international STI and collaborative research. It organizes overall information on research cooperation agreements and initiatives, dividing them into multilateral collaborations, including QUAD and AUKUS, and bilateral collaborations with countries like Japan, China, and India.

5.1 Multilateral Collaboration

5.1.1 QUAD (Quadrilateral Security Dialogue - Quadrilateral Collaboration among Japan, the United States, Australia, and India)

The QUAD is a diplomatic network among the United States, India, Australia and Japan, working towards the realization of a free, open, and resilient Indo-Pacific. To date, three leaders' meetings have been held, discussing a wide range of topics including producing and expanding access to safe and effective vaccines, developing high-standard infrastructure, addressing the climate crisis, collaborating in emerging technologies, space, cybersecurity, and nurturing the next generation of talent[69]. Members have a shared understanding that it is necessary to build an open, accessible, and secure technology ecosystem for critical and emerging technologies. The main QUAD initiatives related to STI are as follows:

[69] Prime Minister's Office "QUAD Leaders' Meeting" accessed on March 28, 2023.
https://www.kantei.go.jp/quad-leaders-meeting-tokyo2022/index_j.html

Table 5-1 Main QUAD Initiatives Related to STI

Themes	Initiative Summary
Vaccines	· Address both the COVID-19 pandemic and prepare for future health crises. · In the long term, strengthen scientific and technological cooperation through clinical trials and genomic surveillance, enhance the global health architecture, and perform pandemic prevention, preparedness, and response (PPR). · Commit increased funding to the Coalition for Epidemic Preparedness Innovations (CEPI) for the next funding round to develop new vaccines for the prevention and containment of infectious diseases.
Climate Change	· Launch the Quad Climate Change Adaptation and Mitigation Package (Q-CHAMP) to promote clean energy and strengthen supply chains. · Enhance resilience to climate change and other disasters.
Cybersecurity	· Collaborate on capacity-building programs in the Indo-Pacific region under the Quad Cybersecurity Partnership, working together to defend against cyber threats. · Commit to aligning fundamental software security standards in government procurement.
Critical and Emerging Technologies	· Promote interoperability and security in the fields of 5G and beyond 5G. · Map the capabilities and vulnerabilities of the Quad countries in the global semiconductor supply chain, aiming for a diverse and competitive semiconductor industry. · Strengthen cooperation through the International Standards Cooperation Network (ISCN). · Continue in-depth discussions on biotechnology. · In the future, focus on quantum technologies and strengthen cooperation in technology trend analysis.
Space	· Collaborate to create frameworks for monitoring and sustainable development based on earth observations. · Provide the Quad Satellite Data Portal, a collection of links to each country's satellite data resources and strive to share civilian earth observation data from space. · Collaborate on the development of space applications in the field of earth observation.
Quad Fellowship	· Annually, aim to have 100 students from Japan, the United States, Australia, and India obtain graduate degrees in STEM fields in the United States. The first cohort of fellows will begin their studies in the third quarter of 2023, jointly cultivating talented next-generation personnel in STEM fields. Offer a unique combination of scholarships, cultural exchange, networking, and educational programs.

Source: Created by the author from the Prime Minister's Office's "QUAD Leaders' Meeting"

The QUAD represents a framework for collaborating to solve common societal and critical issues among the four countries, highlighting the importance of both collaboration on issues and the choice of partners. The QUAD demonstrates that Japan, the United States, Australia, and India share common values. Beyond this framework, Australia is advancing collaboration through AUKUS with the United States, as discussed in the next section, and is actively strengthening relations with India through comprehensive strategic partnerships, the establishment of Centers of Excellence (COEs), and collaboration in cybersecurity. Japan also holds an important position for Australia, and further bilateral cooperation likely has much to offer to Australia. Details on Australia's relations with India will be discussed in the next section, and the strengthening of STI relations and the potential for collaboration between Japan and Australia will be covered in the following chapter.

5.1.2 AUKUS (Australia, United Kingdom, United States Trilateral Security Partnership)

Australia, the UK, and the US have deep relationships produced from various experiences, including Australia's historical background as a British colony, military cooperation in past wars, and the signing of the ANZUS Treaty. Established in September 2021, AUKUS is a security partnership among Australia, the United Kingdom, and the United States. The aim of AUKUS is to bring stability, safety, and prosperity to the Indo-Pacific region. The three countries plan to jointly develop and provide advanced military capabilities to promote security and stability in the Indo-Pacific region.

The AUKUS partnership not only protects Australia's security and geopolitical interests but also enhances Australia's capabilities in science, technology, and innovation, especially in defense-related technologies. Knowledge transfers in underwater robotics, automation systems, quantum technology, artificial intelligence, cybersecurity, and hypersonic technologies have already occurred. The deployment of nuclear-powered submarines is now being planned, with technology transfers from the US and the UK, and joint development of new technologies anticipated.

The plan for Australia's deployment of nuclear-powered submarines was announced on March 13, 2023, at the AUKUS leaders' meeting. ADF personnel will be sent to US and UK submarine bases starting this year for training. Australia plans to purchase three Virginia-class nuclear-powered submarines in the early 2030s, which will be designed by the UK based on the technology of the three countries and built in the UK and Australia[70].

(1) Research Cooperation and Co-authorship between Australia and the USA

An examination of Australia's share of international co-authored papers was performed to assess trends in collaborative research between Australia and the USA. Results revealed that the USA has historically been Australia's top partner country. However, China, ranking second, is significantly increasing its share, while the USA is seeing a decrease in its share. The USA, in particular, maintains a strong presence in fields such as clinical medicine, basic life sciences, and physics (Figure 5-1).

70 U.S. Embassy in Canberra, "AUKUS JOINT LEADERS' STATEMENT (March 14, 2023)," https://au.usembassy.gov/aukus-joint-leaders-statement

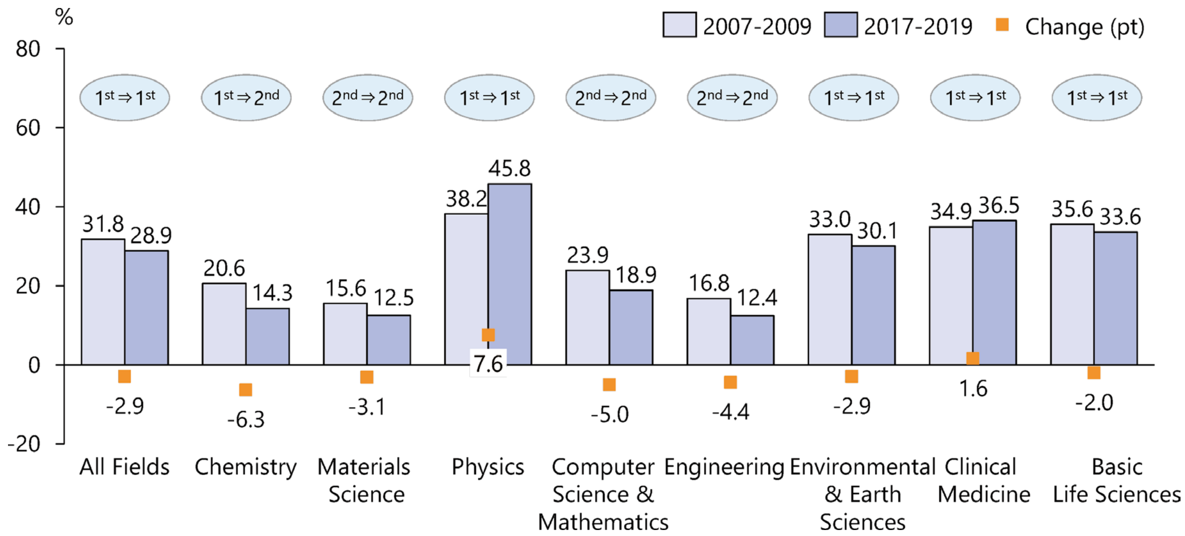


Figure 5-1 International co-authorship status between Australia and the USA from Australia's perspective (co-authorship share & ranking)

Source: Nishikawa Kai et al. (2021) "Benchmarking Scientific Research 2021, NISTEP Research Material, No. 312.", created by the author from the Ministry of Education, Culture, Sports, Science and Technology's National Institute of Science and Technology Policy

An examination of trends in cooperation amongst projects receiving ARC grants from 2018 to 2022 shows that 41.9% (2474) of all projects receiving grants were joint research with the USA, with 1848 of those being STEM-related. The top 5 major research fields were engineering (377), biological sciences (344), physical sciences (220), information and computer science (161), and mathematical sciences (155). The top 5 research institutions participating in joint research with the USA were the University of New South Wales (279), the University of Melbourne (265), the University of Queensland (256), Monash University (232), and the University of Sydney (230)[71].

(2) Research Cooperation and Co-authorship between Australia and the UK

An examination of Australia's share of international co-authored papers was performed to assess trends in collaborative research between Australia and the UK. Results revealed that the UK ranks third after the US and China. Examining trends over time reveals that although its share of papers has increased, the UK has relinquished the second position due to China's overwhelming growth. Like the USA, the UK maintains a particularly strong presence in fields such as clinical medicine, basic life sciences, and physics (Figure 5-2).

[71] ARC, "NCGP Trends: International Collaboration", accessed January 31, 2023.
https://www.arc.gov.au/funding-research/funding-outcome/grants-dataset/trend-visualisation/ncgp-trends-international-collaboration

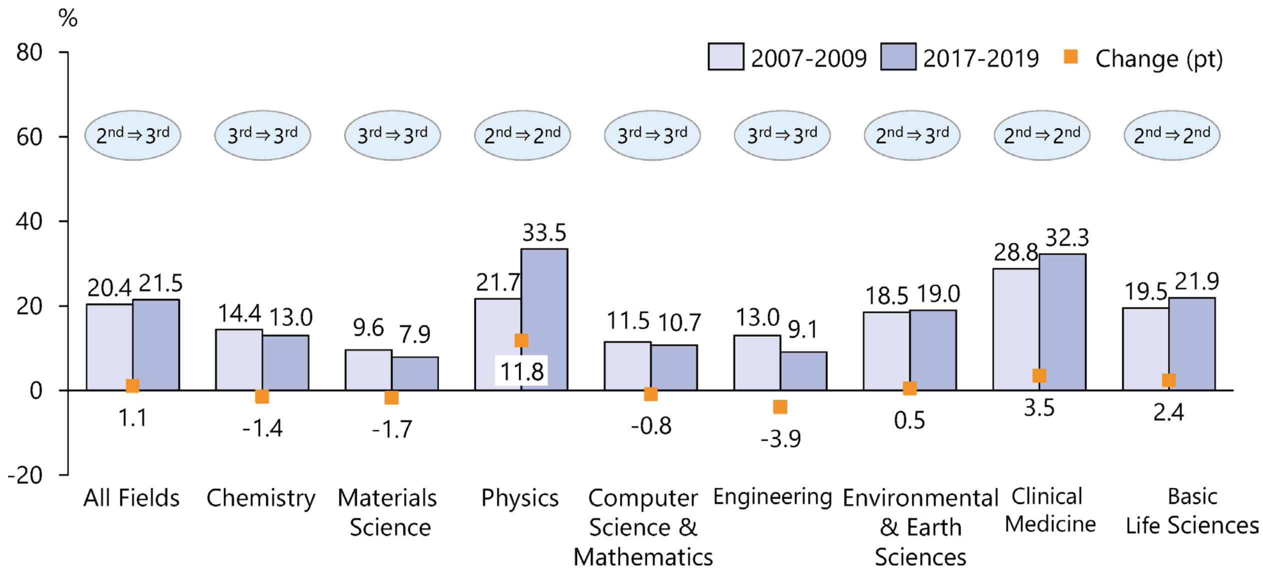


Figure 5-2 International co-authorship status between Australia and the UK from Australia's perspective (co-authorship share & ranking)

Source: Same as Figure 5-1

Between 2018 and 2022, 26.8% (1585) of all ARC-funded projects were joint research with the UK, with 1041 of those being STEM-related. The top 5 major research fields were biological sciences (213), human social studies (155), engineering (140), physical sciences (123), mathematical sciences (92), and chemical sciences (92). The top 5 research institutions participating in joint research with the UK were Monash University (191), the University of Melbourne (175), the University of New South Wales (151), the University of Queensland (146), and the University of Sydney (145)[72].

5.2 Bilateral Collaboration

5.2.1 Overview of Japan-Australia Relations

(1) Trends in Science and Technology Cooperation Between Japan and Australia

Australia and Japan have had a long-standing cooperative relationship in the domain of STI, complementing each other in focus areas and research and development capabilities, making them important partners for each other.

The Agreement with the Government of Japan on Cooperation in Research and Development in Science and Technology, concluded in 1980, linked researchers and research institutions, strengthened bilateral cooperation and promoted the sharing of scientific information. Additionally, the Australian and Japanese governments have strengthened their collaboration through forums to share policy approaches for developing STEM skills. The key outcomes from their 40 years of partnership are below[73].

72 Same as reference 72

73 DISR, "Australia and Japan: 40 years of international collaboration on science, technology and innovation (November 27, 2020)", https://www.industry.gov.au/news/australia-and-japan-40-years-international-collaboration-science-technology-and-innovation

- Long-term joint research at the KEK Photon Factory in Tsukuba
- Scientific drilling and investigation of seabed geology
- Landing of Japan's asteroid probe Hayabusa I in Woomera, South Australia

Australia and Japan are collaborating to tackle common challenges through science and technology, with recent joint research including:

- Development of mutually beneficial industries and low-emission gas technologies to drive post-COVID economic recovery
- Improvement of agricultural productivity
- Building a sustainable energy supply chain using hydrogen
- Protecting critical coral reefs from crown-of-thorns starfish
- Responding to natural disasters using cutting-edge technology

Despite the presence of long-standing cooperation and symbolic programs, a different perspective emerges when the international co-authorship situation between Australia and Japan is examined. Japan's co-authorship share in Australia, which was 5.6% between 2007 and 2009, decreased to 5.4% between 2017 and 2019. As a result, its ranking as a co-authorship partner country has dropped from 8th to 10th. By field, while maintaining its 5th position in chemistry and materials science, physics has fallen from 5th to 9th place. Engineering, environmental and earth sciences, and basic life sciences, which were within the top 10, are now ranked lower than 10th place. Although many leading countries are increasing their co-authorship rates with Australia, Japan is struggling to maintain its share, resulting in a decrease in presence in all fields with Australia (Figure 5-3).

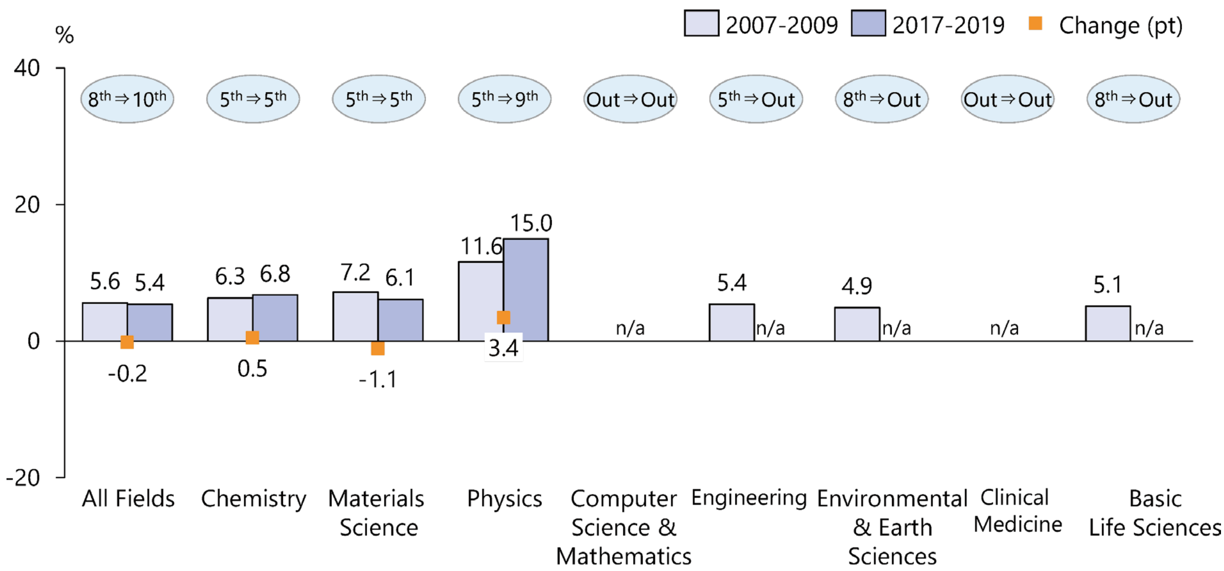


Figure 5-3 International co-authorship status between Australia and Japan from Australia's perspective (co-authorship share & ranking)

Source: Same as Figure 5-1

Conversely, a different situation can be seen when examining the international co-authorship situation from Japan to Australia. Compared to 10 years ago, Australia's co-authorship share has risen from 4.3% to 7.6%, moving from 9th to 7th place as a co-authorship partner country. Except for physics, Australia is a top 10 partner country in chemistry, materials science, computer science and mathematics, engineering, environmental and earth sciences, clinical medicine, and basic life sciences, with notable increases in share and in rank across many fields (Figure 5-4).

The significant growth in co-authorship with Australia compared to the overall growth in international co-authorships from Japan underscores the increasing importance of Australia to Japan. Australia, however, is promoting international collaborations with countries other than Japan to a greater extent, leading to a decline in Japan's position. This trend may further reduce Japan's share of international co-authorships. While international co-authorships alone cannot define the relationship in the STI domain between two countries, it's necessary to acknowledge that Japan's positioning and environment may not always be positive.

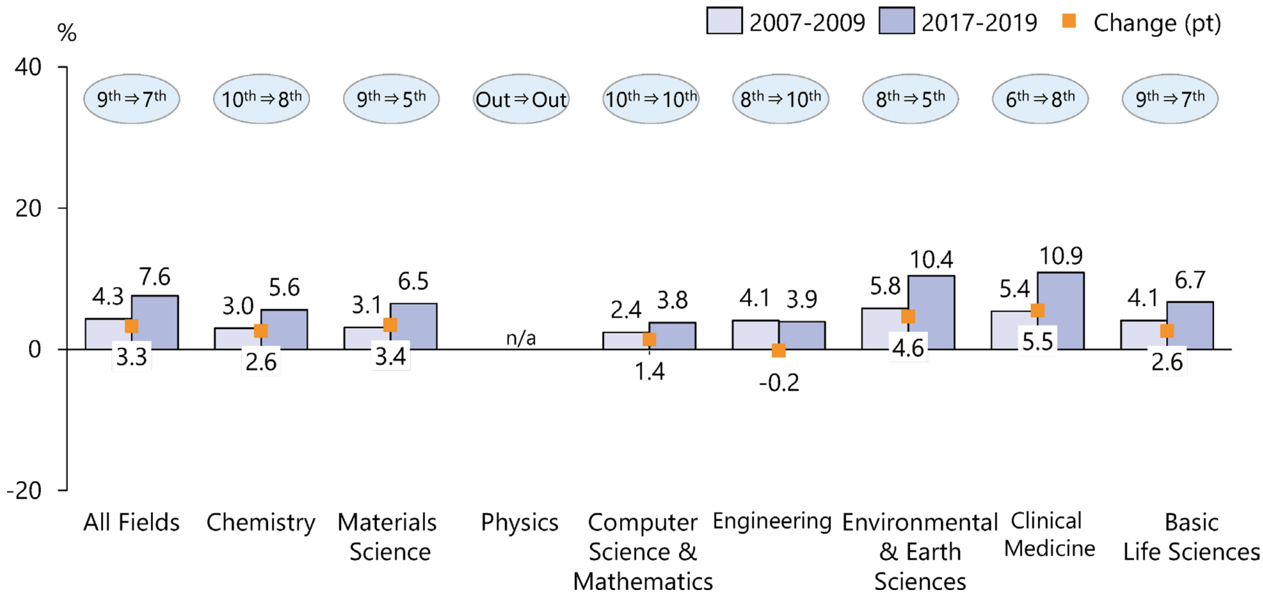


Figure 5-4 International co-authorship status between Japan and Australia from Japan's perspective (co-authorship share & ranking)

Source: Same as Figure 5-1

(2) Examples of Technical Cooperation Between Japan and Australia (Joint Research)

Between 2018 and 2022, 6.1% (358 projects) of all projects funded by the ARC involved international cooperation with Japan, of which 305 were related to STEM. The top 5 major research fields were engineering (78), physical sciences (66), biological sciences (37), mathematical sciences (29), and chemical sciences (28). The top 5 research institutions participating in joint research with Japan were the University of Queensland (45), Australian National University (41), University of Melbourne (40), University of Sydney (38), and the University of New South Wales (34).[74]

[74] Same as reference 72

(3) Examples of Technical Cooperation Between Japan and Australia (Personnel Exchange)

Australia has engaged in international research exchanges with Japan for many years. For example, the Emerging Research Leaders Exchange Program (ERLEP), aimed at nurturing the next generation of research leaders, has been facilitated by the cooperation of three organizations: the Japan Society for the Promotion of Science, the Engineering Academy of Japan, and the Australian Academy of Technological Sciences and Engineering, providing opportunities for researchers from Japan and Australia in applied research areas to visit each other's research institutions. The exchange of researchers between Japan and Australia had been occurring at a steady rate, but there was a decrease in human exchanges in 2020 due to COVID-19 (Figure 5-5).

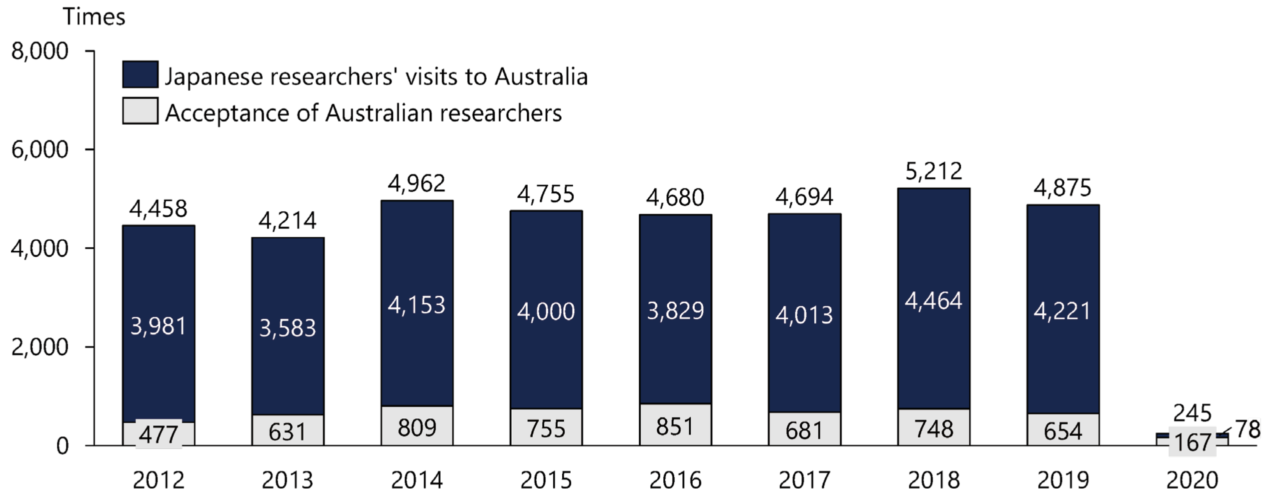


Figure 5-5 Exchanges of researchers between Japan and Australia

Source: Created by the author from the Ministry of Education, Culture, Sports, Science and Technology's "Overview of International Research Exchange (2012-2020)"

(4) Examples of Technical Cooperation Between Japan and Australia (Specific Cases)

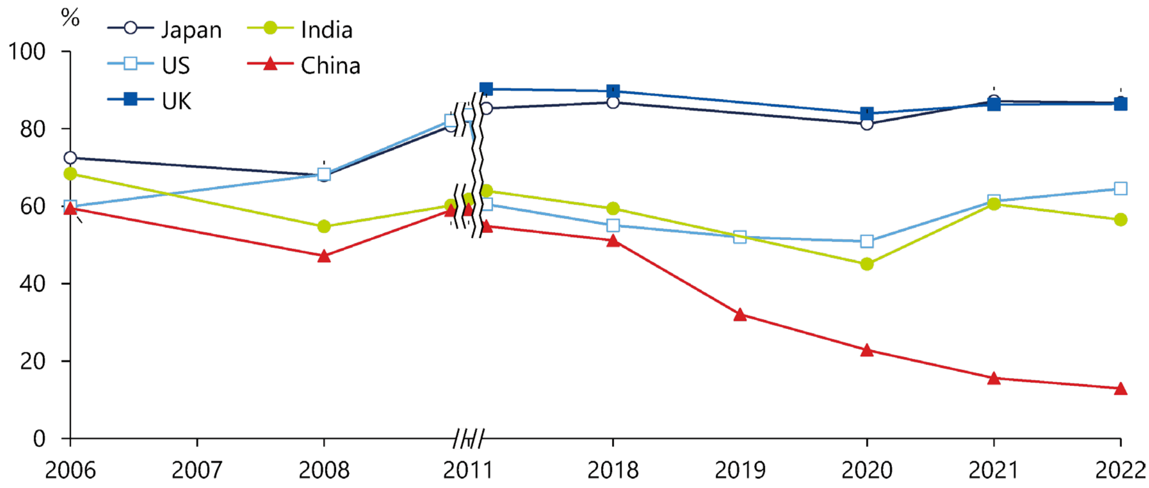
As a unique example of Japan-Australia cooperation, Kyushu University established the Australian Branch of the Institute of Maths for Industry at La Trobe University in March 2015[75]. As part of the Kyushu University Top Global University Project, the initiative aims to employ researchers locally and serve as a base for mathematical and mathematical science research collaboration and human exchange - including students - and involving the industry sector in the Oceania region.

(5) Hopes for Japan

Amid the emergence of destabilizing elements, such as COVID-19 and the Russia-Ukraine war, public perceptions

[75] Kyushu University "Establishment of an International Collaboration Base for Industrial Mathematics in Australia (February 19, 2015)" https://www.imi.kyushu-u.ac.jp/post-1205/

toward specific countries are changing. According to a Lowy Institute survey, Japan is recognized by Australians as a country that acts responsibly, and its trustworthiness has been increasing year by year as shown in the following figure (Figure 5-6). As Australia seeks to study critical technologies with a trusted partner, the significance of Japan being trusted not only at the governmental level but also by the citizens is evident, suggesting room for collaborative efforts in areas where Japan can leverage its strengths.



Note: Combining "very trustworthy" and "somewhat trustworthy"

Figure 5-6 Trends in the Australian Public's Trust Regarding Taking Responsible Actions

Source: Created by the author from Lowy Institute's "2022 Lowy Institute Poll reports"

5.2.2 Overview of Australia-China Relations

Australia and China celebrated its 50th anniversary of diplomatic relations in December 2022. Due to China's rapid growth, it has become Australia's largest trading partner in both exports and imports. While economically a significant partner, the bilateral relationship has not been entirely smooth. Especially under the previous administration, tensions between the two countries increased due to various issues related to politics, technology, and industry. Public sentiment has also changed, with a Lowy Institute survey showing a shift in views towards China, peaking in 2018. By 2022, the number of respondents who saw China as a threat exceeded those who saw it as an economic partner. Specifically, 63% of respondents perceived China as a security threat, greatly exceeding the 33% who saw it as an economic partner. (Figure 5-7).

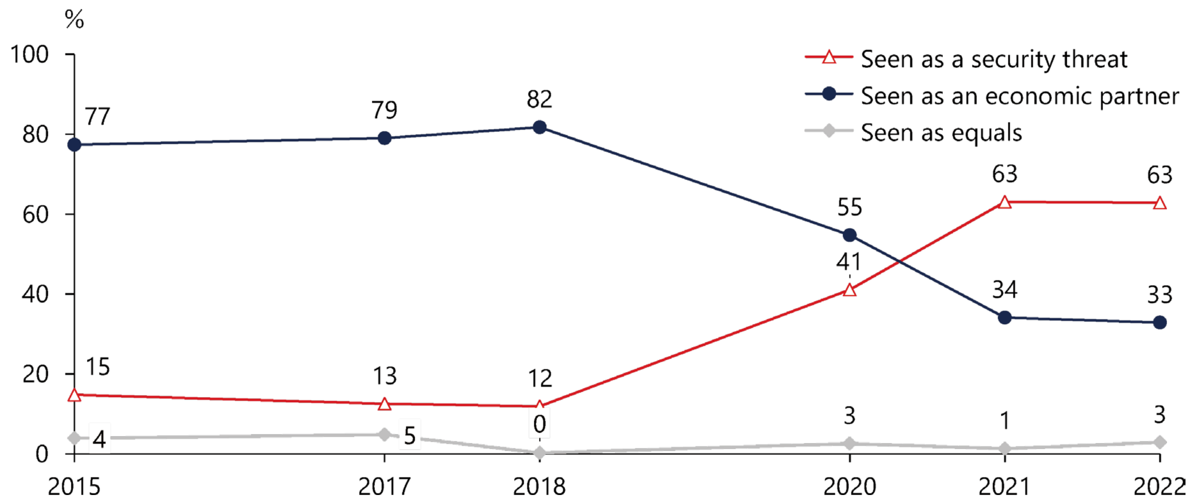


Figure 5-7 Shift in Australian views towards China

Source: Same as Figure 5-6

In 2014, Australia and China agreed to elevate their relationship to a comprehensive strategic partnership, covering areas of mutual interest such as economy, trade, investment, infrastructure, society, and education, with the aim of fostering a reciprocal relationship. The China-Australia Free Trade Agreement (ChAFTA), which came into effect in December 2015, has brought significant benefits to both countries[76]. China is Australia's largest trading partner, accounting for one-third of Australia's total trade volume. China is also the sixth-largest source of foreign direct investment in Australia. In terms of education, initiatives such as the New Colombo Plan helped make Australia a popular overseas study destination for Chinese students before the pandemic. In terms of research, the National Foundation for Australia-China Relations has provided grants for joint projects in areas such as education and science, strengthening the ties between the two countries[77].

Although their socio-economic relationship has been favorable, the two countries have a differing geopolitical and security stance. Australia has sought to contain China's influence in the Pacific and South Asia by establishing partnerships such as AUKUS and QUAD.

The lack of transparency shown by China after the outbreak of COVID-19 has led to a cooling of socio-economic relations between Australia and China. This tension between the two governments led to the termination of projects funded under the Australia-China Science and Research Fund (ACSRF) and the closure of joint research centers. As relations deteriorated, the Australian government announced a critical technologies list and revised the "Guidelines to counter foreign interference in the Australian university sector" in November 2021 (Table 5-2) to counter foreign interference, Restrictions on research cooperation with overseas institutions, including China, have sparked debate

[76] DFAT, "China-Australia Free Trade Agreement", accessed January 31, 2023. https://www.dfat.gov.au/trade/agreements/in-force/chafta/Pages/australia-china-fta

[77] DFAT, "China country brief Bilateral relations", accessed January 31, 2023. https://www.dfat.gov.au/geo/china/china-country-brief

among universities and researchers[78 79].

Table 5-2 Risk Management Measures in Research Cooperation

	Initiative	Overview
2012	Enactment of the Defence Trade Control Act (DTCA) 2012	A law regulating the international export of military technology.
2018	Enactment of the Foreign Interference Transparency Scheme Act	A continuously updated protection against foreign interference and technology smuggling from the university sector.
2019	University Foreign Interference Task Force (UFIT)	A function for Australian government agencies to guide the university sector based on the significance of risks.
2020	Enactment of Export Control Act	A law requiring government approval for the export of intellectual property to certain countries.
2021	Announcement of the Critical Technologies List	Prime Minister Scott Morrison announced a list of critical technologies to limit sharing with foreign entities. The Straits Times discussed this list as part of the measures to protect sensitive technologies from foreign (Chinese) interference[80].
2021	Guidelines to Counter Foreign Interference in the Australian University Sector	While it is important for Australia's continuous growth to remain globally open, these guidelines were revised in November 2021 to protect against threats while maintaining benefits from international cooperation. The guidelines cover governance and risk, communication, education and knowledge sharing, proper evaluation, risk assessment and management, and cybersecurity[81]. They are not focused on any specific country, and the method of implementation is left to each university. University representatives and relevant organizations will discuss the implementation of the guidelines, with reports planned for 2023.

Source: Created by the author from public information

On November 15, 2022, at the G20 Summit held in Indonesia, Chinese President Xi Jinping and Australian Prime Minister Anthony Albanese held talks after a long diplomatic freeze. This was the first formal meeting between the nations' leaders since 2016. The discussion, primarily about trade, confirmed the high degree of complementarity in their economies. Although the meeting was seen as a thaw in bilateral relations, improvements in the countries'

78 Universities Australia, "SUBMISSION TO THE PROTECTING CRITICAL INFRASTRUCTURE AND SYSTEMS OF NATIONAL SIGNIFICANCE CONSULTATION (September 2020)", https://www.universitiesaustralia.edu.au/wp-content/uploads/2020/11/200916-Universities-Australia-Critical-Infrastructure-submission.pdf

79 Dr. Ross McLennan, "Balancing collaboration and security: a high-wire challenge for Australia's universities", Australian Institute of International Affairs, 8th June 2021. https://www.internationalaffairs.org.au/resource/balancing-collaboration-and-security-a-high-wire-challenge-for-australias-universities/

80 "Australia looks to ring-fence sensitive tech from foreign interference", *The Straits Times*, 17th November 2021. https://www.straitstimes.com/asia/australianz/australia-looks-to-ringfence-sensitive-tech-from-foreign-interference

81 DoE, "Guidelines to Counter Foreign Interference in the Australian University Sector (November 17, 2021)", https://www.education.gov.au/guidelines-counter-foreign-interference-australian-university-sector/resources/guidelines-counter-foreign-interference-australian-university-sector

relationship will depend on future developments. The main trends in Australian-Chinese relations are as below.

Table 5-3 Trends in Bilateral Relations between Australia and China

Years	Chinese President	Australian Prime Minister	Main Events
1972	Mao Zedong	Gough Whitlam (Labor)	· Establishment of diplomatic relations between Australia and China
1989	Deng Xiaoping	Bob Hawke (Labor)	· Tiananmen Square incident · Extension of temporary entry permits for Chinese nationals, extension of visas for Chinese students
1996	Jiang Zemin	Paul Keating (Labor)	· Taiwan Strait Crisis
As above	As above	John Howard (Liberals)	· Tension in Australia-China relations due to Howard's meeting with the Dalai Lama
2003	Hu Jintao	As above	· Speech by the Chinese President in the Australian Parliament
2007	As above	As above	· Proposal of the Quadrilateral Security Dialogue (QUAD) by Prime Minister Abe · Meeting between John Howard and the Dalai Lama
2008	As above	Kevin Rudd (Labor)	· Australia announces withdrawal from QUAD · Takeover battle over Rio Tinto by Chinese state-owned enterprise Chinalco · Rudd raises the Tibet issue in meeting with President Hu Jintao
2009	As above	As above	· Australian government allows visit by President of the World Uyghur Congress
2013	Xi Jinping	Julia Gillard (Labor)	· Australia and China agree to establish a strategic partnership · Signing of a currency agreement for direct trading between the AUD and the yuan
As above	As above	Tony Abbott (Liberals)	· Australia excludes Huawei (China) from the National Broadband Network project
2014	As above	As above	· Visit by President Xi Jinping to Australia. Agreement to elevate the Australia-China relationship to a Comprehensive Strategic Partnership
2015	As above	Malcolm Turnbull (Liberals)	· Northern Territory authorities sign a 99-year lease agreement with a Chinese company for commercial port facilities in Darwin · Establishment of the Australia-China FTA · Australia joins the Asian Infrastructure Investment Bank as a founding member · Amendment of the Foreign Acquisitions and Takeovers Act 1975 to revise the foreign investment review system. Chinese companies are blocked from acquiring farmland and power utilities as "contrary to the national interest" under the system. Contracts involving state government agencies included as subjects of review under the Foreign Acquisitions and Takeovers Act

2017	As above	As above	· Resignation of Senator Sam Dastyari (opposition Labor Party), who had made statements effectively supporting China's claims in the South China Sea and was found to have received support from a Chinese businessman · Australian Security Intelligence Organisation's Director-General Duncan Lewis warns of foreign government interference in universities, specifically with China in mind
2018	As above	As above	· Introduction of the Foreign Influence Transparency Scheme Act 2018, requiring registration and disclosure of information on clients and activities · Enactment of the Security of Critical Infrastructure Act 2018
2019	As above	Scott Morrison (Liberals)	· Quadrilateral Security Dialogue (QUAD) ministerial meeting among Japan, the United States, Australia, and India, from which Australia withdrew during the Rudd administration, is realized
2020	As above	As above	· Australia calls for an independent investigation into the origins of COVID-19 in China · China introduces the Hong Kong National Security Law · Extension of visas for Hong Kong citizens staying in Australia to pave the way for permanent residency. The extradition treaty with Hong Kong was also suspended. · Enactment of Australia's Foreign Relations (State and Territory Arrangements) Act 2020, requiring prior notification to and approval from the Foreign Minister for state, territory, and universities, among others, to enter into arrangements with foreign governments
2021	As above	As above	· Cancellation of the Belt and Road Initiative agreement signed independently by the State of Victoria in 2018 · The first QUAD leaders' meeting was held, confirming the strengthening of cooperation in various fields such as vaccines and infrastructure towards the realization of a 'free and open Indo-Pacific' · China announces an indefinite suspension of all activities based on the "Strategic and Economic Dialogue" held since 2014 · It is revealed that the Morrison administration is considering revising the lease agreement for Darwin Port, signed in 2015, from a security perspective, including the addition of usage restrictions · Announcement of the establishment of the AUKUS security framework with the US and UK, further strengthening defense relations · Declaration of a diplomatic boycott of the Beijing Olympics due to several issues, including human rights violations, by the Chinese government
2022	As above	Anthony Albanese (Labor)	· QUAD US-Japan-Australia-India Leaders' Meeting · 50th Anniversary of Australia-China Relations · Australia-China diplomatic and strategic dialog held in Beijing (Foreign Ministers' Meeting)

Legend: (Labor) Labor Party, (Liberals) Liberal Party. The presidents and prime ministers at the time of events or implementation are listed

Source: Created by the author from the Australian Government's Public Information, Treasury "Australia-China Bilateral Relations - The Future of Australia-China Disputes"

As can be seen by their co-authorship of papers, it is apparent that both China and Australia are important partners to each other. China's presence has risen to be on par with the United States in international co-authorship, holding first or second position in many fields except clinical medicine and basic life sciences where the US and UK have strengths. China is overwhelmingly in first place in some fields. China's presence is gradually increasing even in the fields of clinical medicine and basic life sciences, where it was behind the US and UK, and the gap with the US and UK could further narrow (Figure 5-8).

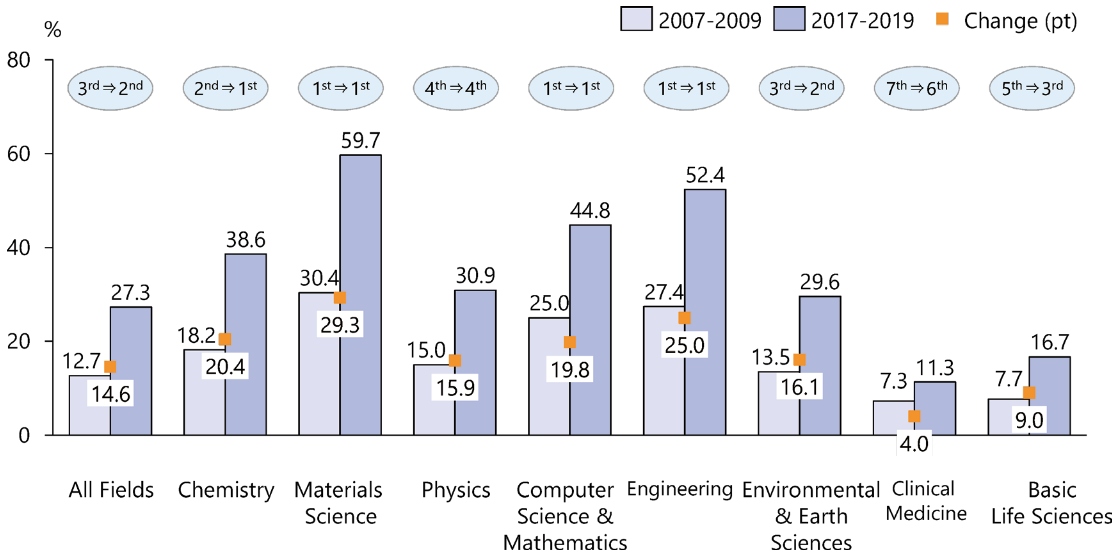


Figure 5-8 International co-authorship status between Australia and China from Australia's perspective (co-authorship share & ranking)

Source: Same as Figure 5-1

Australia is also an important partner for international cooperation to China. The US is China's number one international co-authorship partner in all 8 fields, but Australia is the second or third in many (Figure 5-9). Co-authorship has increased for both countries in the past decade, differing from the situation with Japan, where, from Australia's perspective, the share is falling.

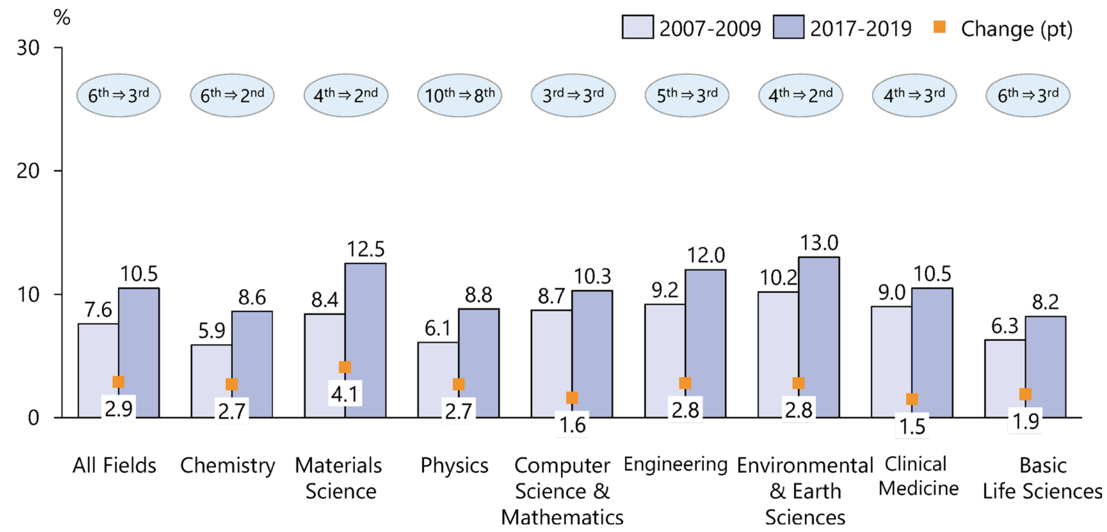


Figure 5-9 International co-authorship status between China and Australia from China's perspective (co-authorship share & ranking)

Source: Same as Figure 5-1

The Australian government is generally maintaining an open stance in promoting international joint research and it can be assumed that research cooperation with China will continue. On the other hand, due to government risk management measures, it is likely that building cooperative relationships will be difficult in areas highly related to military and defense among critical technologies. It can also be assumed that collaboration may become difficult in other critical technology areas.

Based on debates[82] and interviews among researchers, it can be seen that many appreciate China's research capabilities and view collaboration with China positively. In some cases, collaboration with China is seen as essential for improving Australia's research capabilities. However, government officials overseeing critical technologies and those involved in military research and other areas feel that collaboration with China is risky. It is important to understand that there are differences in attitudes toward relations with China among different stakeholders.

Furthermore, examining projects funded by the ARC from 2018 to 2022, 11.4% (671 projects) involved international cooperation with China, with 556 being in STEM fields. The top 5 research fields were engineering (241), information and computational science (63), mathematical sciences (43), physical sciences (43), and technology (43). The top 5 research institutions participating in joint research with China were Monash University (69), University of Queensland (69), University of Melbourne (58), University of New South Wales (54), and the University of Sydney (46) (Figure 5-10).

Although the share and number of projects are not insignificant, they are significantly lower compared to the international co-authorship ratio, indicating that projects utilizing ARC competitive funding are not actively engaging in collaboration with China.

82 Same as reference 80

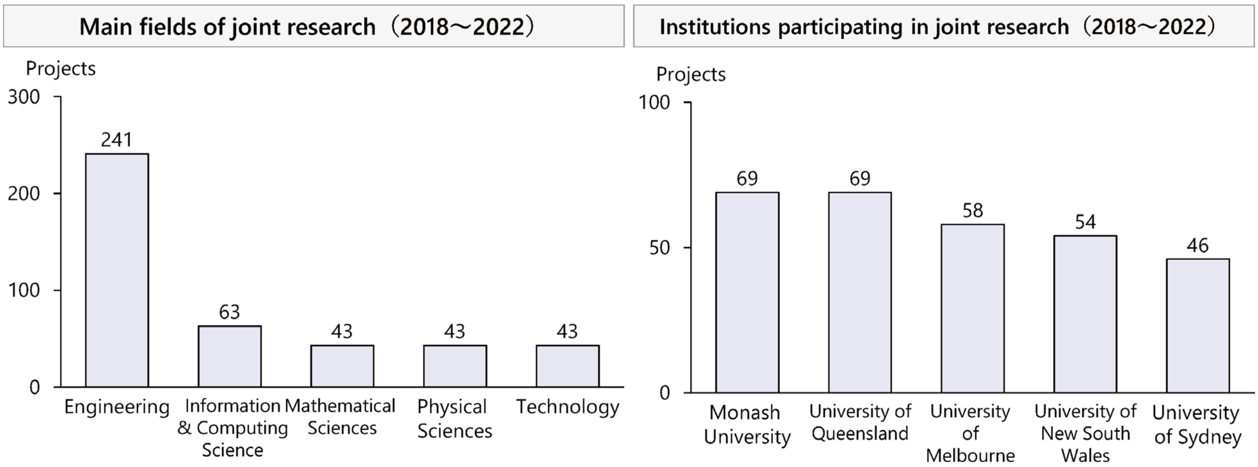


Figure 5-10 China's Presence in Projects Receiving Grants from ARC (Fields & Collaborating Research Institutions)

Source: Created by the author from ARC's "The National Competitive Grants Program dataset"

5.2.3 Overview of Australia-India Relations

For Australia, India is the nation with which it holds the oldest diplomatic ties in Asia. For India, Australia was the first country with which it established diplomatic relations. India and Australia agreed to a strategic partnership in 2009 and upgraded their bilateral relationship to a Comprehensive Strategic Partnership in 2020. Based on the conclusion of the partnership, both countries agreed to cooperate in areas such as science, technology, maritime cooperation, economy, defense, agriculture, education, and tourism. Both countries are developing important diplomatic policies such as the Comprehensive Economic Cooperation Agreement (CECA), the Australia-India Economic Cooperation and Trade Agreement (ECTA) developed from CECA, and the Joint Working Group (JWG) on Defence Research and Material Cooperation[83]. Their relationship so far is as follows.

83 DFAT, "India Country and trade information," accessed January 31, 2023. https://www.dfat.gov.au/geo/india

Table 5-4 Transitions in Bilateral Relations between Australia and India

Years	Indian Prime Minister	Australian Prime Minister	Main Events
1947	Jawaharlal Nehru (INC)	Ben Chifley (Labor)	· Indian Independence
1992	Narasimha Rao (INC)	Paul Keating (Labor)	· Establishment of the Australia-India Council (AIC) to explore business opportunities
2006	Manmohan Singh (INC)	John Howard (Liberals)	· Signing of a defence cooperation memorandum and establishment of the Australia-India Strategic Research Fund (AISRF)
2009	As above	Kevin Rudd (Labor)	· Joint declaration on security cooperation · Agreement on strategic partnership
2014	Narendra Modi (BJP)	Tony Abbott (Liberals)	· Agreement on a bilateral framework for security cooperation
2015	As above	As above	· Start of annual bilateral military exercise AUSINDEX
2019	As above	Scott Morrison (Liberals)	· India withdraws from the Regional Comprehensive Economic Partnership (RCEP) negotiations
2020	As above	As above	· Upgraded to a Comprehensive Strategic Partnership · Mutual Logistics Support Agreement signed · Framework agreement on cooperation in critical cyber technologies · Joint declaration on a vision for maritime cooperation in the Indo-Pacific
2021	As above	As above	· Joint statement on the first India-Australia 2+2 Ministerial Dialogue · The first QUAD leaders' meeting was held, confirming the strengthening of cooperation in various fields such as vaccines and infrastructure towards the realization of a 'free and open Indo-Pacific'
2022	As above	As above	· Joint statement on the first India-Australia Foreign Ministers' Cyber Framework Dialogue · Signing of the Economic Cooperation and Trade Agreement (AI-ECTA)
As above	As above	Anthony Albanese (Labor)	· QUAD US-Japan-Australia-India Leaders' Meeting

Legend: (INC) Indian National Congress, (BJP) Bharatiya Janata Party, (Labor) Labor Party, (Liberals) Liberal Party. The prime ministers at the time of events or implementation are listed

Source: Created by the author from public information published by the Australian Government

From the perspective of research and development grants, joint grant schemes such as the Australia-India Strategic Research Fund (AISRF), the Australia-India Cyber and Critical Technology Partnership (AICCTP), and the Australia-India Indo-Pacific Oceans Initiative Partnership (AIIPOIP) have been launched to promote joint research and development for new technologies and defense. Below is an overview of the Australia-India Strategic Research Fund as an example.

Table 5-5 Overview of the Australia-India Strategic Research Fund (AISRF)

Funding Agencies	DISR
Purpose	· Promote cutting-edge scientific and technological research by supporting collaboration between researchers from both countries in strategic areas. · Strengthen strategic alliances between Australian and Indian researchers. · Facilitate access for Australian and Indian researchers to the global science and technology community.
Program Overview	Support Australian organizations and Indian partners working on research projects in priority areas.
Program Features	· Indian partners must submit applications to the corresponding program of India's DST (Department of Science and Technology) or DBT (Department of Biotechnology). · Grants are available for priority areas specified by the funding agency.
Funding Amount	500,000 to 1,000,000 AUD per project. Total of 6 million AUD.
Project Duration	Within 3 years
Note	Round 15 applications opened on January 16, 2023 (deadline March 15, 2023). Since the establishment of the program in 2006, the Australian Government has supported over 360 projects, fellowships, workshops, etc.

Source: Created by the author from the Australian Government's "Funding for Australian and Indian collaborative research projects"

The Australian Government announced the establishment of a Centre of Excellence for Critical and Emerging Technology Policy (COE) in India on November 17, 2021. The COE brings together Australian and Indian engineers, policy practitioners, academics, researchers, and thinkers to tackle policy challenges of the digital age. It is an initiative for developing key technologies and complements the Australia-India Cyber and Critical Technology Partnership. It aims to identify investment opportunities in cyber, critical, and emerging technologies, promote cutting-edge technological innovation, and strengthen partnerships. Amid constraints in collaboration with China, the Australian Government has indicated an intention to actively and comprehensively advance cooperation with India in economics, military, cybersecurity, and other areas.

Examining the relationship between India and Australia from the perspective of international co-authorship, India's presence as seen from Australia has changed compared to 10 years ago. Specifically, a certain level of presence has been observed in fields such as chemistry, material science, computer science/mathematics, and engineering. However, India is not in the top 10 in many areas, and its presence in international co-authorship compared to the United States, China, the United Kingdom, and Japan is limited (Figure 5-11).

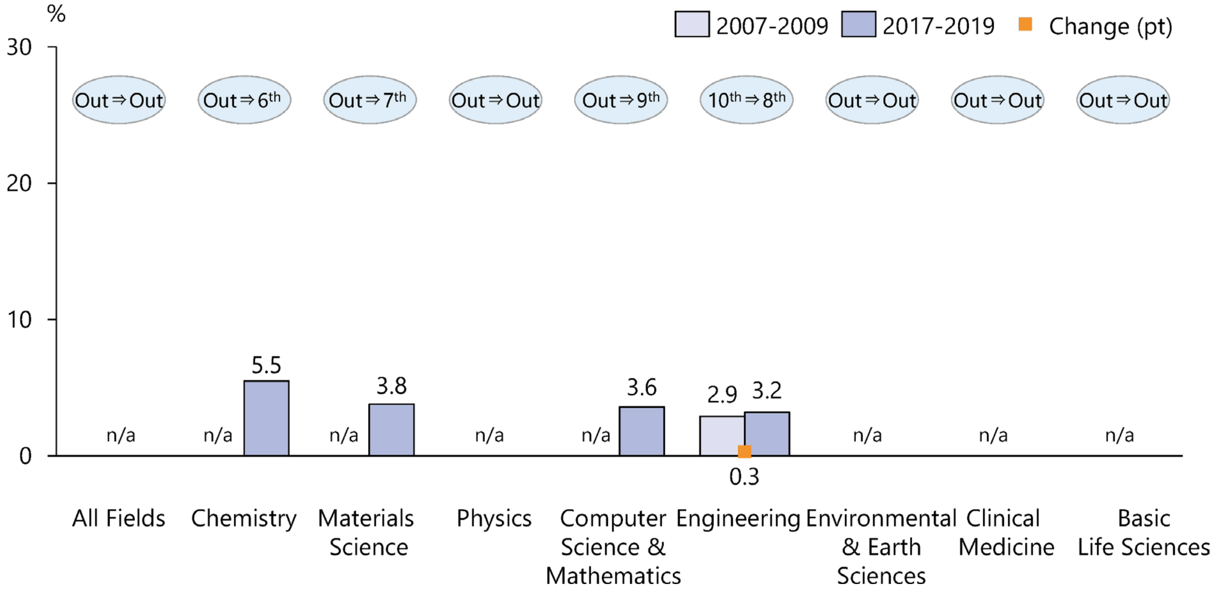


Figure 5-11 International co-authorship status between Australia and India from Australia's perspective (co-authorship share & ranking)

Source: Same as Figure 5-1

Conversely, Australia's international co-authorship presence as seen from India has greatly improved. India's main international co-authorship partners are the United States, the United Kingdom, and China, but its share of co-authorship is increasing in general. Australia ranks 6th overall, it is particularly high in clinical medicine (rank 3rd), environmental & earth sciences (rank 5th), and basic life sciences (rank 5th) (Figure 5-12).

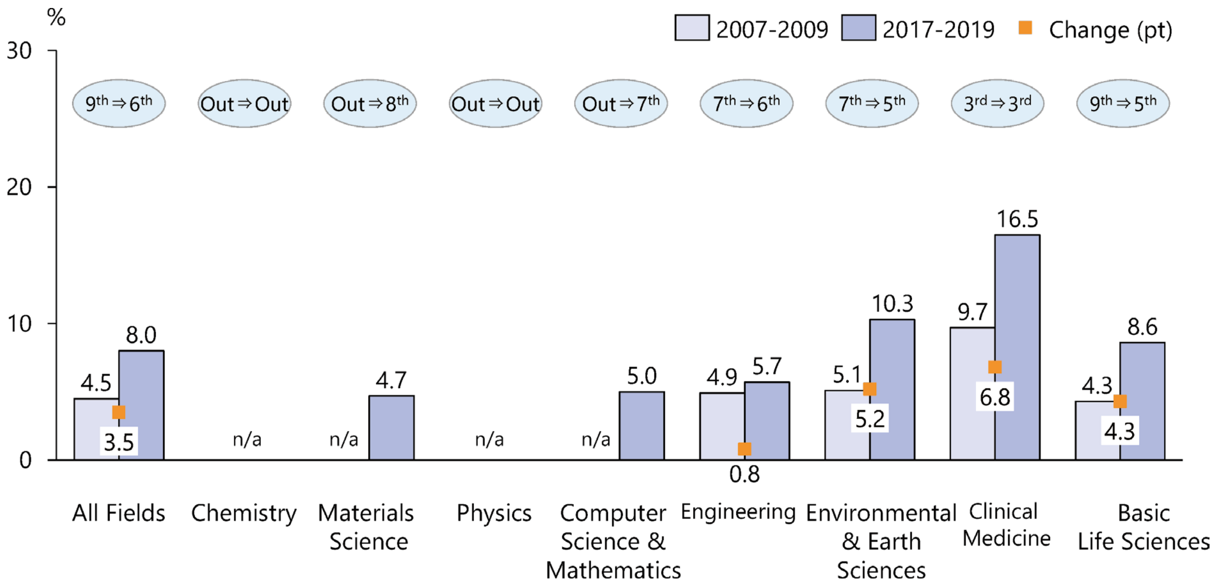


Figure 5-12 International co-authorship status between India and Australia from India's perspective (co-authorship share & ranking)

Source: Same as Figure 5-1

6 Implications for Japan-Australia STI Policy

This survey report has clarified the differences in the science and technology environment between Japan and Australia. In terms of inputs, Australia has seen an increase in research and development expenditures alongside economic growth, with research and development expenditures nearly quadrupling compared to 20 years ago. Additionally, Australia actively welcomes renowned researchers and graduate students from around the world, and the number of research personnel in universities and similar institutions has also increased. This increase in research funding and renowned researchers allows for engagement in more sophisticated and large-scale research, resulting in an increase in the number of papers, including those in the top 10% and top 1% of papers. In addition, Australia is characterized by a high rate of international collaboration, promoted by the government and funding bodies like the ARC, enhancing collaboration with leading researchers overseas and leading to an improvement in the quality of outputs. The increase in research inputs and an environment that supports international collaboration has led to a positive cycle of good research outputs, further enhancing its research capabilities.

Japan is a strategic partner of Australia, and the two countries have conducted symbolic joint research efforts. However, as Australia actively pursues joint research with other countries, the share of co-authored research with Japan has decreased, and Japan has been unable to sufficiently demonstrate its presence in the research scene. Nevertheless, with the new government's upcoming new STI policy and changes to handling of critical technologies, security responses, approaches to societal challenges, etc., Australia also has many challenges and needs in the field of STI. By leveraging the good relationship between Australia and Japan and the strengths of Japan's research areas, both countries have room to expand and deepen their STI cooperation (Table 6-1).

Table 6-1 Australia's Main Challenges/Needs in the Field of STI and Value Japan Can Provide

	Australia's Main Challenges/Needs	Value Japan Can Provide
1	Selection of appropriate partners for research related to critical technologies.	Japan is a partner country that shares common values with Australia, making it a reliable collaborator for cooperation.
2	Promotion of research in important areas such as critical technologies, responses to societal challenges (environment, energy, etc.), industries with strengths (medical, bio, etc.), and industries that earn foreign currency and create jobs in regional areas (resources, agriculture, etc.).	In multiple areas where Australia has recognized challenges, Japan has comprehensive strengths in everything from basic to applied research, enabling it to contribute to resolving these challenges.
3	Connecting research outcomes to industry (not ending in research).	Beyond university research, Japan has many leading companies in various industries, enabling linear and comprehensive collaboration and contributions through industry-academia collaboration from basic research to experimental development.

Source: Created by the author based on interviews

Japan and Australia are both advanced countries in the field of science and technology and can create synergies by leveraging each other's strengths in this area. The increasingly unstable environment surrounding their societies creates an opportunity for the two countries, who have established mutual trust, to take the next step to strengthen their collaboration.

A. Areas where both countries acknowledge common challenges (recognition that implementation of the challenges is important for the development of the country's economy, society, and science and technology; hereinafter the same shall apply in this section) (such as healthcare, hydrogen energy, and cyber-AI) ,B. Areas where Australia identifies challenges that Japan can help address (such as advanced manufacturing like robotics, positioning, navigation, timing, and communication) and C. Areas where Japan identifies challenges that Australia can help address (such as medicine, biotechnology, genetic engineering, etc.) are ripe for collaboration. Furthermore, D. Areas where Australia has strengths (e.g., agriculture, mining, medical & bio, genetic engineering, etc.) and E. Areas where Japan has strengths (e.g., transportation equipment, satellites, etc.) could be further enhanced through collaboration. When expanding and deepening their STI cooperation, collaboration through multifaceted programs, agreements that are political (and not just practical), the establishment of bases with investment, and the involvement of diverse stakeholders through industry-academia-government collaboration platforms will further strengthen the commitment between both parties to cooperate.

6.1 Collaboration Scheme

The authors of this report examined a scheme for strengthening collaboration in the field of STI between Japan and Australia. To strengthen the relationship between the two countries, it's crucial to increase and enhance the points of contact between Japan and Australia. As a foundation for collaboration, establishing a joint investment pool and a Japan-Australia Industry-Academia-Government Collaboration Platform are key steps. For individual initiatives, we considered six program proposals: collaboration coordinators, Japan-Australia Centers of Excellence, joint research bases, joint academic conferences and symposiums, exchanges of research talent, and support for budding and young researchers. The overall scheme diagram (Figure 6-1) and the content of each initiative are as follows.

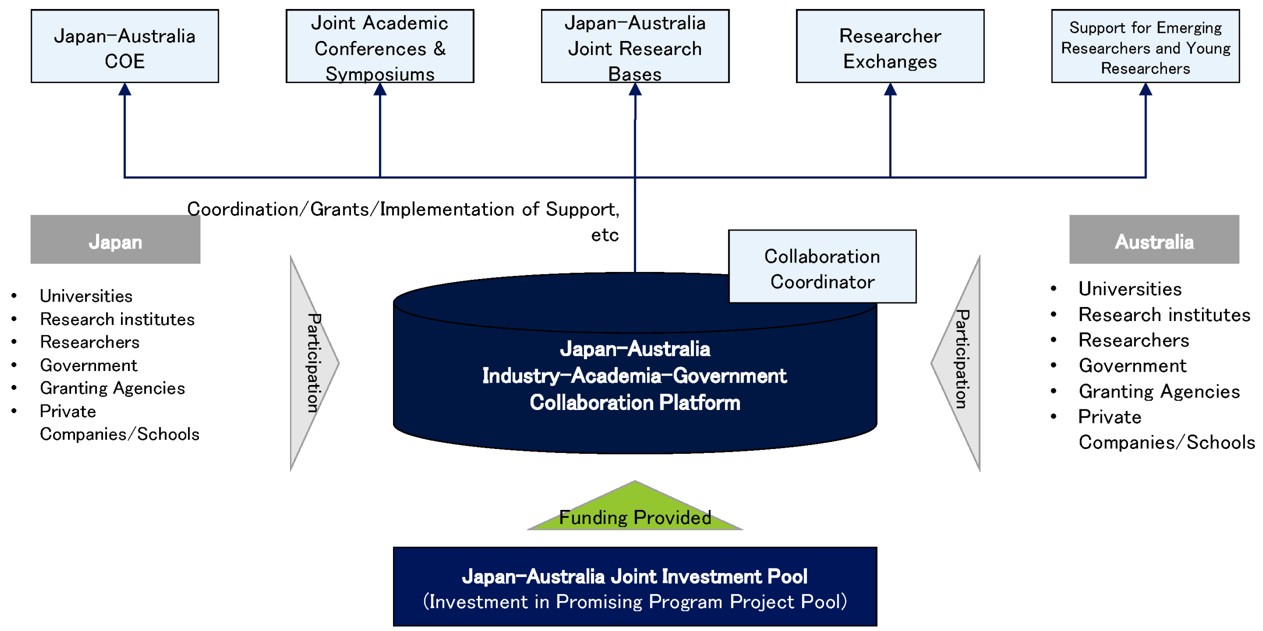


Figure 6-1 Japan-Australia Collaboration Scheme

Source: Created by the author

(1) Japan-Australia Joint Investment Pool

Form a fund to invest in programs and projects that contribute to the promotion of scientific and technological cooperation between Japan and Australia. Programs contributing funds include platforms to promote industry-academia-government collaboration between Japan and Australia (see below), coordination projects to support collaboration, joint academic conferences, the establishment of joint research bases, researcher exchanges, etc. Projects to consider include grants to Japan-Australia projects and the implementation of joint calls in multilateral collaborations.

(2) Japan-Australia Industry-Academia-Government Collaboration Platform

Form a platform to promote scientific and technological cooperation between universities, governments, companies, and broader society in Japan and Australia. The Australian government has a strong recognition of the challenges in commercializing research outcomes, and involving companies in the platform is expected to attract the interest of the Australian government and universities, etc. Build a collaboration platform covering all stages of research, from basic, to applied, and experimental development research.

(3) Collaboration Coordinator

A catalyst is necessary to effectively utilize platforms as tools. Locate collaboration coordinators who can quickly and accurately understand the challenges and needs of Australian universities and researchers on site, and pitch Japanese research institutions and researchers as solutions. The coordinators will function as sales representatives, promoting Japan-Australia scientific and technological cooperation on-site. They will also support collaboration when Japanese companies consider joint research with local universities and research institutions.

(4) Japan-Australia COE

Referencing the Australian-India COE, designate themes that can be tackled through Japan and Australia's relationship and shared values in areas of critical technologies, etc., where both sides share challenges, and launch COEs to collaborate on solving issues and conducting research and development.

(5) Japan-Australia Joint Research Bases

Set up international joint research bases where researchers from both countries physically and virtually gather in research areas where strength from both countries can be utilized, such as hydrogen energy, involving private companies working on hydrogen energy development to engage in joint research.

(6) Joint Academic Conferences & Symposiums

Host academic conferences and international symposiums centered around researchers from Japan and Australia, build a network of related researchers, and lay the foundation for promoting Japan-Australia scientific and technological cooperation.

(7) Researcher Exchanges

In areas where ongoing research cooperation is important for Japan and Australia, conduct long-term mutual dispatch of researchers to maintain and strengthen networks of related researchers.

(8) Support for Emerging Researchers and Young Researchers

Provide opportunities for promising future researchers and young researchers from Japan and Australia to participate in international research activities, helping cultivate the next generation of researchers. For example, QUAD's fellowships (where students from Japan, Australia, and India attend graduate schools in the United States) will begin in 2023. Constructing a similar mechanism between Japan and Australia and mutually accepting research candidates will build a foundation for Japan-Australia scientific and technological cooperation.

6.2 Areas of Collaboration

Together with the collaboration scheme, the authors considered in which fields and themes Japan and Australia should deepen their collaboration.

The results of scientific and technological research contribute to social and economic development, the solution of both national and global issues, and to exploration of unknown academic fields.

Due to this there are great incentives for cooperation between Japan and Australia that contribute to these areas in both countries. From this perspective, areas where both countries are aware of issues (Those recognized as important for the economic, social, scientific, and technological development of the country concerned, and applicable to the remainder of this paragraph), or where one side is aware of an issue and the other can contribute to it are major candidates for deepened cooperation. Additionally, in order to robustly promote the resolution of issues and to contribute to the development of unknown academic fields, close collaboration in areas in which either one country is strong, or both are, will lead further improvement of the strengths and scientific and technological capabilities of both countries and are prime candidates for increased collaboration.

Based on this mindset, the authors have identified the following five areas where room for collaboration between Japan and Australia is expected and cooperation should be deepened:

A. Areas where both countries share awareness of issues (e.g. Healthcare, Hydrogen/Energy, Cybersecurity/AI).

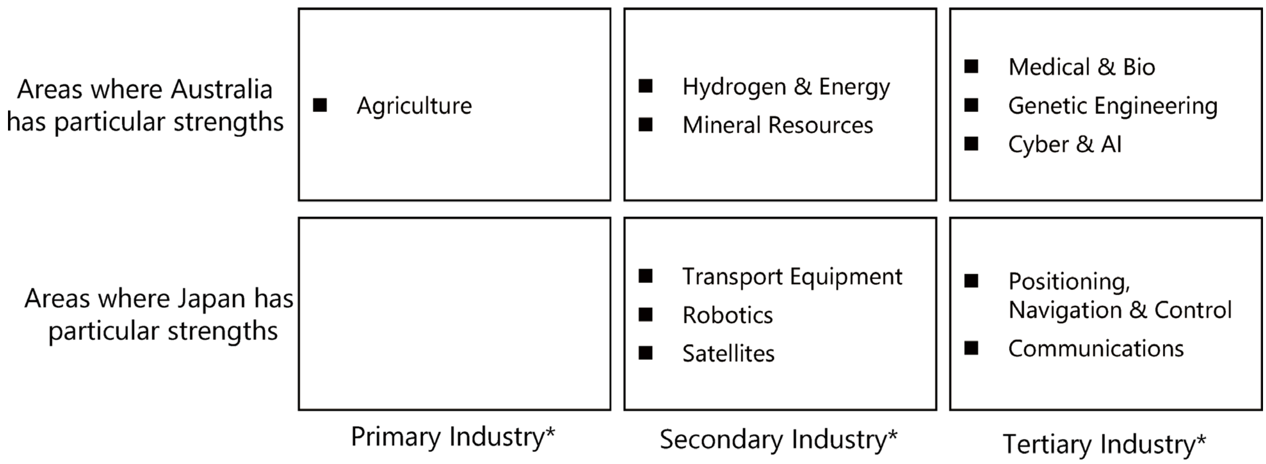
B. Areas of high importance to Australia to which Japan can contribute (e.g. Advanced manufacturing of robots, positioning, navigation, timekeeping, communications).

C. Areas of high importance to Japan to which Australia can contribute (e.g. Medicine, biotechnology, genetic engineering).

D. Areas in which Australia has strengths, such as agriculture, mining, medicine, biotechnology and genetic engineering.

E. Areas in which Japan has strengths, such as transport equipment and satellites.

Cooperation in areas where either one country, or both, have strengths will lead to the search for effective solutions to problems and further strengthening of the science and technology capabilities in each. Moreover, as the researchers themselves are able to proactively lead cooperation, the process will be relatively simple, and results will be easy to obtain.



*Note: Based on the Japanese Standard Industrial Classification

Primary Industry: Agriculture, Forestry, Fisheries
Secondary Industry: Industry, Construction, Manufacturing
Tertiary Industry: Industries other than the aforementioned and those that cannot be classified

Figure 6-2 Organizing the Potential for Scientific and Technological Collaboration with Australia

Source: Created by the author

Australia showcases particular strengths in several areas: amongst primary industries, agriculture stands out; amongst secondary, hydrogen, energy and mining are prominent; and amongst tertiary, there are significant strengths in medical & bio, genetic engineering, and cyber & AI technologies. On the other hand, Japan demonstrates distinct strengths in secondary industries with transportation equipment, robots, and satellites, and in the tertiary sector with positioning, navigation & timing, and communication technologies. In the sectors where Japan excels, it can significantly contribute to research and development efforts in Australia, enhancing and deepening these fields.

Likewise, in sectors where Australia has strengths, Japan can offer its extensive research capabilities to further deepen research efforts. Hence, collaboration potential should be considered not only in areas where Japan has strengths but also in areas where Australia has strengths. Opportunities for collaboration in each area are introduced below.

(1) Agriculture

Japan is an important export partner for Australian agricultural and fishery products, importing grain such as wheat, along with meat and seafood from Australia[84]. As mentioned previously, the current Minister for Agriculture, Fisheries, and Forestry and Emergency Management has set priorities including strengthening the national biosecurity system, promoting sustainable and environmentally friendly agriculture, fisheries, and forestry, and aiming to grow the agriculture, fisheries and forestry sector to 100 billion AUD by 2030. Australia is, therefore, making serious considerations towards agriculture. Japan and Australia, despite differences in soil and climate conditions, have similarities regarding the importance they place on agriculture and the diverse research they are engaged in. Additionally, since Japan is the second-largest export destination for Australia, it is also an important partner from an economic perspective, and there is considerable room for collaboration towards the goal of strengthening both countries' industries.

(2) Energy & Environment: Hydrogen & Ammonia

Japan is an important resource export partner for Australia, with the country heavily relying on energy resources from Australia. Hydrogen and ammonia are next-generation energy sources with a low environmental impact, and Australia has designated hydrogen and ammonia as critical technologies and positioned them as priority themes. In addition to being critical technologies, hydrogen and ammonia are critical industrial foundations for supporting regional economies after the energy transition. They are also vital from the perspectives of local employment and the revitalization of regional economies[85]. Japan and Australia announced the Japan-Australia Partnership on Decarbonization through Technology on June 13, 2021, agreeing to work on decarbonization through technologies such as clean fuel ammonia, clean hydrogen, and carbon recycling[86]. Japan, with its strengths in hydrogen and ammonia research and clusters of industries actively involved in this field, can demonstrate advantages in bridging research outcomes to industry.

(3) Advanced Manufacturing: Mining Engineering

Mining is an important industry for Australia from the perspectives of resource export and revitalization of the regional economy, and mining technology is designated as a critical technology for advanced manufacturing. It is also positioned as a priority theme. Japan and Australia signed the Critical Minerals Partnership on October 22, 2022, announcing cooperation between Japan and Australia to build a critical mineral supply chain between the two countries, establish a framework for promoting mutually beneficial investments, and develop Australia's critical

84 AUSTRADE "Agricultural and Fishery Products, Flowers, Plants," accessed March 28, 2023.
https://www.austrade.gov.au/local-sites/japan/buy-from-australia/industry-information/f-b-agri

85 Japan External Trade Organization "An additional AUD 150 million to develop a hydrogen hub (September 22, 2021)"
https://www.jetro.go.jp/biznews/2021/09/bab01efabba1bd71.html

86 Ministry of Foreign Affairs "Japan-Australia Partnership on Decarbonization through Technology (June 13, 2021)"
https://www.mofa.go.jp/mofaj/files/100199969.pdf

mineral industry and secure mineral resources needed by Japan[87]. Japan, which imports many resources from Australia, collaborates with the Australian government, related companies, research institutions, and universities through the Japan Organization for Metals and Energy Security (JOGMEC), an independent administrative agency under the Agency for Natural Resources and Energy, conducting exploration activities, resource development support, demonstration experiments, and joint research. Although Japan's domestic mines are limited, the research and development capabilities of public research institutions, universities, and private companies can contribute to the development of mining engineering in Australia, and Japanese resource development companies, mining machinery manufacturers, and plant manufacturers can also serve as connections for research outcomes, demonstrating Japan's advantages.

(4) Robots

Australia faces challenges due to its vastness and the inaccessibility of the harsh inner continent. While its population is increasing, aging is making it difficult to secure workers. Securing labor is a particular problem in rural areas, and the use of industrial robots, drones, mechanization, and automation is being actively considered. Japan has strengths in the manufacturing sector and leads the world in industrial robots which are used in fields such as automobile manufacturing. Additionally, as its population rapidly ages, researchers are working on broad themes related to assistance robots that can support work efficiency and humanoid robots. Japan possesses strengths in fundamental research on robotics, including advanced precision control technology, and has capabilities and strengths throughout the entire supply chain. Australia is aware of Japan's strengths in this field, and the possibility of collaborating in areas of emerging technology such as AI and robotics engineering was discussed at the 59th Australia-Japan Business Partnership meeting held in October 2022[88]. Although there are not yet any Memorandums of Understanding (MoU) related to robotics between the Japanese and Australian governments, this is an area where Japan can demonstrate its advantages to Australia by leveraging its expertise.

(5) Medical & Bio

Australia possesses world-class research achievements in the medical and bio field, deeply collaborating with top runners like the USA and the UK, producing both large numbers and high quality papers. From an outcome perspective, it has produced numerous Nobel Prize-level researchers in the fields of physiology and medicine. As mentioned earlier, significant input is being invested to produce high-level outputs and outcomes, with the NHMRC providing competitive funding in the medical field instead of the ARC, and the MRFF supporting large projects. Additionally, at the private level, multiple Western pharmaceutical companies, including the domestically based CSL, have located research and development functions in Australia.

From the perspective of collaboration between Japan and Australia, the 17th Japan-Australia Joint Committee on

87 Ministry of Economy, Trade and Industry "Partnership on Critical Minerals Signed with the Australian Department of Industry, Science, and Resources and the Department of Foreign Affairs and Trade (October 25, 2022)" https://www.meti.go.jp/press/2022/10/20221024002/20221024002.html

88 Japan Chamber of Commerce and Industry "59th Australia-Japan Business Partnership Meeting, October 9-11, 2022 (Tokyo) (October 14, 2022)" https://www.jcci.or.jp/%E7%AC%AC59%E5%9B%9E%E6%97%A5%E8%B1%AA%E7%B5%8C%E6%B8%88%E5%90%88%E5%90%8C%E5%A7%94%E5%93%A1%E4%BC%9A%E4%BC%9A%E8%AD%B0%20%E5%85%A8%E4%BD%93%E4%BC%9A%E8%AD%B0%E6%A6%82%E8%A6%81.pdf

Science and Technology Cooperation was held in November 2022, and included life sciences as one of the topics discussed[89]. In the past, initiatives such as the Japan-Australia Joint Symposium on Drug Design and Development and the Japan-Australia Medical Research Symposium have been conducted. The Japan Agency for Medical Research and Development has implemented the Japan-Australia Joint Call for Strategic International Collaborative Research Program (SICORP) for Early Career Researchers with NHMRC, and various related initiatives are now underway[90]. However, examining international co-authorship among Australia's clinical medicine and basic life sciences reveals Japan is not among the top 10 collaboration partners in either field. However, deepened cooperation will likely allow it to catch up.

(6) Positioning, Navigation, and Timing Technologies

Positioning, navigation, and timing are technologies used across various industries, and the Australian government believes these technologies could generate over 73 billion AUD in cumulative value domestically by 2030[91]. To seize these opportunities, the Australian government has created a PNT roadmap and launched several related projects, including military-use projects by the DSTG. To improve accuracy in positioning, navigation, and timing, Positioning Australia is utilizing Japan's quasi-zenith satellite system, Michibiki. Positioning, navigation, and timing are designated as critical technologies by Australia, and Japan has already contributed to this field, including through Michibiki. This area is where Japanese universities and research institutions have strengths, and they can contribute to the realization of the roadmap set forth by Australia. In addition, Japanese companies have a global presence in the field of positioning, making it possible to propose industrial bridging and industry-academia collaboration.

Japan and Australia have formed a good relationship both politically and economically, making them important strategic partners in various fields. Although there has been collaboration in the field of STI, it has often been on a relatively small scale, one-off, or performed as needed in-the-field. However, as vital agendas such as security and social issues emerge, strengthening the STI relationship between Japan and Australia holds significance for both parties and marks an opportune time for enhancing collaboration. Collaborating in STI between the two countries will not only advance science and technology but also produce economic benefits, ensure the nations' security, solve social issues, and deepen cultural and human exchanges, benefiting both. This report aims to trigger the deepening of collaboration in STI between the two nations, we hope that it contributes to strengthening bilateral relations.

89 Ministry of Foreign Affairs "The 17th Japan-Australia Joint Committee Meeting on Science and Technology (November 30, 2022)" https://www.mofa.go.jp/mofaj/press/release/press3_001005.html

90 Japan Agency for Medical Research and Development "FY 2022 Japan-Australia Joint Call for Strategic International Collaborative Research Program (SICORP) for Early Career Researchers (April 27, 2022)" Accessed January 31, 2023. https://www.amed.go.jp/en/news/program/2001B_00015.html

91 Geoscience Australia, "About Positioning Australia" Accessed March 3, 2023. https://www.ga.gov.au/scientific-topics/positioning-navigation/positioning-australia/about-the-program

7 Appendix

7.1 List of Figures

7.2 List of Tables

7.3 Abbreviations List

Abbreviation	English and Japanese Formal Names
ADF	オーストラリア国防軍 (Australian Defence Force)
AIMS	オーストラリア海洋科学研究所 (The Australian Institute of Marine Science)
AISRF	豪印戦略研究基金 (The Australia-India Strategic Research Fund)
ANSTO	オーストラリア原子力科学技術機 (Australian Nuclear Science and Technology Organisation)
ARC	オーストラリア研究会議 (Australian Research Council)
ARENA	オーストラリア再生可能エネルギー庁 (Australian Renewable Energy Agency)
ASX	オーストラリア証券取引所 (The Australian Securities Exchange)
ATN	オーストラリア技術大学ネットワーク (Australian Technology Network of Universities)
AUD	オーストラリアドル (Australian dollar)
AUKUS	豪英米パートナーシップ (Australia, United Kingdom, United States)
AUSMURI	オーストラリアおよびアメリカの学際的大学研究イニシアチブ（Australia-US Multi-disciplinary University Research Initiative）
BERD	民間部門の研究開発費支出（Business expenditure on research and development）
BRII	ビジネス・リサーチ・アンド・イノベーション・イニシアチブ (Business Research and Innovation Initiative)
BTF	バイオメディカル・トランスレーション・ファンド (Biomedical Translation Fund)
CBRN	化学・生物・放射性物質・核（Chemical, biological, radiological and nuclear）
CECA	包括的経済協力協定（The Comprehensive Economic Cooperation Agreement）
CEFC	クリーンエネルギー金融公社 (Clean Energy Finance Corporation)
COE	センターオブエクセレンス（Centre of Excellence）
CRC	協働研究センタープログラム (Cooperative Research Centers Programs)
CRCHBP	ミツバチ製品共同研究センター (The Cooperative Research Centre for Honeybee Products)
CRC-P	協働研究センタープロジェクト (Cooperative Research Centers Projects)
CRDC	綿花研究開発公社 (Cotton Research and Development Corporation)
CSIRO	オーストリア連邦科学産業研究機構（Commonwealth Scientific and Industrial Research Organisation）
DAFF	農業・漁業・林業省（The Department of Agriculture, Fisheries and Forestry）
DCCEEW	気候変動・エネルギー・環境・水資源省（Department of Climate Change, Energy, the Environment and Water）
DFAT	外務貿易省（The Department of Foreign Affairs and Trade）
DHAC	保健・高齢者介護省（Department of Health and Aged Care）
DIIS	産業・イノベーション・科学省（Department of Industry, Innovation and Science）

DISR	産業科学資源省（Department of Industry, Science and Resources）
DLT	DST リーダーシップチーム (DST leadership team)
DoD	国防省（Department of Defence）
DoE	教育省（Department of Education）
DoF	財務省（Department of Finance）
DSTG	国防科学技術グループ (Defence Science and Technology Group)
DTA	デジタル変革庁（Digital Transformation Agency）
FA	助成機関（FA: Funding Agency）
FFMA	未来基金管理庁 (Future Fund Management Agency)
FRDC	水産研究開発公社 (Fisheries Research and Development Corporation)
GDP	国内総生産（Gross Domestic Product）
GERD	研究開発費支出（Gross domestic expenditure on research and development）
GEOINT	地理空間情報（Geospatial Intelligence）
GII	グローバル・イノベーション・インデックス（Global Innovation Index）
GNSS	全地球測位衛星システム (Global Navigation Satellite System)
GOVERD	政府機関の研究開発費支出（Government expenditure on research and development）
Go8	グループ・オブ・エイト（The Group of Eight）
GRDC	穀物研究開発公社 (Grains Research and Development Corporation)
GVA	実質総付加価値額（Gross Value Added）
HERD	高等教育機関の研究開発費支出（Higher education expenditure on research and development）
IRU	革新的研究大学グループ (Innovative Research Universities)
JSPS	日本学術振興会 (Japan Society for the Promotion of Science)
JST	国立研究開発法人科学技術振興機構 (Japan Science and Technology Agency)
MMI	モダン製造業イニシアチブ（Modern Manufacturing Initiative）
MRFF	医療研究未来基金 (Medical Research Future Fund)
MURI	学際的大学研究イニシアチブ（Multidisciplinary University Research Initiative）
NCRIS	国家共同研究基盤戦略（National Collaborative Research Infrastructure Strategy）
NCGP	国家競争的資金プログラム（The National Competitive Grants Program）
NGTF	次世代技術基金（Next Generation Technologies Fund）
NHMRC	国立保健医療研究会議（National Health and Medical Research Council）
NISA	国家イノベーション・科学アジェンダ（National Innovation Science Agenda）
NEDO	New Energy and Industrial Technology Development Organization

NRF	国家再生基金（National Reconstruction Fund）
NRI	国家研究インフラ（National Research Infrastructure）
NSRP	国家科学研究優先分野（National Science Research Priorities）
NSS	国家科学声明 (National Science Statement)
PCT 出願 (PCT Application)	特許協力条約（Patent Cooperation Treaty）に基づく国際出願 (Patent Cooperation Treaty-Based International Application)
PNPERD	民間非営利機関の研究開発費支出（Private non-profit expenditure on research and development）
PNT	測位・航法・測時（Positioning, Navigation and Timing）
QUAD	日米豪印戦略対話（Quadrilateral Security Dialogue）
RD&E	研究開発および普及活動（Research Development and Extension）
RUN	地方大学ネットワーク（Regional University Network）
SIEF	科学産業基金 (Science and Industry Endowment Fund)
STaR	科学・技術・研究（Science, Technology and Research）
STI	科学技術イノベーション（Science, technology and innovation）
国研 (National Research Institutes)	国立研究機関 (National Research Institutions)

7.4 Foreign Exchange Rates (Officially Announced)

The foreign exchange rates for March 28, 2023, are as follows.

	TTS (Telegraphic Transfer Selling Rate)	TTB (Telegraphic Transfer Buying Rate)	TTM (Average of TTS and TTB)
1 Australian Dollar	89.74 yen	84.74 yen	87.24 yen

Source: “Mizuho Bank Foreign Exchange Rates,” Accessed March 28, 2023. https://www.mizuhobank.co.jp/market/quote/

7.5 Interview Overview

(1) Interview with policy-making bodies (Conducted on February 1, 2023)

Questions	Summary of Responses
STI in Australia	· In 2015, with the establishment of NISA and NSRP, the direction for Science, Technology, and Innovation (STI) was clarified, highlighting a focus on important areas and a few specialized fields. Additionally, there was a strengthened intention to seek commercial returns on research investments by connecting research outcomes with the industry.
Challenges in STI	· Australia faces constraints on research resources (researchers and research funding). Therefore, when engaging in research, it is necessary to focus on specific areas as mentioned above. Collaboration with external, renowned researchers is necessary. Understanding the importance of focusing efforts and leveraging external resources, it is believed that the country's commitment to the direction of STI and the emphasis on international collaboration will remain unchanged.
Critical Technologies	· The Australian government has announced critical technologies, among which quantum technology (quantum communication, etc.), robotics (domestic, and as part of space technology), artificial intelligence, and agricultural technologies such as hydroponics to sustain food production are deemed particularly important.
International Cooperation in STI Fields (Excluding Japan)	· In regard to open access and data sharing, the National Science Engagement Strategy outlines the nature of partnerships with domestic and international collaborative institutions. · Relations with China, including in research, have cooled since COVID-19, partly due to a lack of transparency from China. As a result, projects under the Australia-China Science and Research Fund (ACSRF) were ended, and joint research centers were closed. The Australian government has issued documents such as "Balancing Collaboration with Security" and "A Challenge for Universities", indicating the need for universities to take a balanced approach when conducting joint research with foreign institutions, including China. The Australian government is tackling the management of critical technologies and IP leakage through regulatory measures such as the Defence Trade Control Act established in 2012 and the Export Control Act of 2020, while promoting autonomous actions by universities. · This discussion is not limited to China, it also includes Russia, Yemen, Iran, etc.
International Cooperation in STI Fields (Japan)	· Quantitatively, international collaboration with Japan may not match that with the United States or China. However, focusing on the content and quality reveals interesting research cooperation, making Australia and Japan valuable research partners. · Australia and Japan have a good relationship, and Japan is seen as a safe and reliable partner. Therefore, both countries should promote cooperation in research more than ever. Although this is partially personal opinion, areas such as the nuclear sector (nuclear physics, nuclear power generation, nuclear medicine), geological sciences (crust, minerals, extracts), and space, etc., are likely fields of cooperation with Japan. Furthermore, agriculture and fisheries are also areas of possible cooperation
Direction of STI	· A new direction for STI by the Albanese government will be presented in September 2023, but it is likely that the focus on important areas and a few specialized fields will remain unchanged. · Based on previous government announcements, it is highly likely that messages will be issued regarding climate change, indigenous Australians, and emerging technologies that bring growth and benefits to the nation. · International cooperation will continue to be emphasized, and partner countries will also be deemed important

(2) Interview with Funding Agencies (Conducted on March 2, 2023)

Questions	Summary of Responses
STI in Australia	· Each ministry has a research budget, funding agencies, and research institutions. Representative ministries include the DISR, DoE, and DHAC. As for funding agencies, the DISR has the CSIRO (both a funding agency and a research institution), the DoE has the ARC, and the DHAC has NHMRC. As for research institutions, the DISR has the CSIRO and ANSTO, and the DoE has universities. · Each ministry covers related topics under its jurisdiction, such as health, earth sciences, and climate change. Universities under the DoE deal with a broad range of themes. Most fundamental research is undertaken by universities, funded by block grants from DoE, competitive funding from the ARC or NHMRC, and tuition fees (especially from international students).
Challenges in STI	· Although NISA and NSRP presented directions and priority areas in 2015, they have been criticized for being mere signaling. That is, they lack complementary measures to drive growth in priority areas. · There are also indications that research outcomes are not being effectively bridged to industry, leaving results underutilized.
ARC Grant Programs	· One of the ARC's most important programs is the COE (Linkage Program). It involves substantial grant amounts and is designed to engage industrial partners, with the hope of bridging research outcomes to industry. · Similarly, there is an increase in grant programs (applied research & experimental development) aimed at connecting research outcomes with industry.
Critical Technologies and Protections for Them	· Fields listed as critical technologies will be focus areas moving forward. However, there has been no announcement from the ARC or NHMRC urging focus on these areas. · While there are multiple guidelines for the protection of critical technologies, most do not specify prohibitions but provide a high-level framework, encouraging research institutions like universities to make autonomous decisions. · However, various ministries have established their own rules and guidelines, and restrictions on international cooperation are increasing.
International Cooperation in STI Fields (Excluding Japan)	· The reason for such extensive collaboration with countries like the USA, UK, Germany, and Canada is due to their socio-economic similarities (language, major economic sectors, research investment areas). They are friendly nations, and the government is positive about collaboration with them. · However, there is a gap in perception between the government and researchers regarding collaboration with China. Individual researchers are interested in conducting good research without political considerations. Therefore, they want to collaborate with proactive and talented Chinese researchers. Conversely, the government, concerned about technology outflow and misuse, is not necessarily positive about cooperation, especially in certain critical technology fields.
International Cooperation in STI Fields (Japan)	· Health is closely linked to societal challenges and is one of the fields where cooperation is expected. Japan has signed a bilateral agreement with the NHMRC to conduct joint research on aging, dementia, and other topics. · In fields other than health, there is the potential for cooperation in areas such as manufacturing and marine science. One hope for collaboration with Japan is the industrial sector. There is an awareness of the need to strengthen connections with the industrial sector, so it is believed that there is high interest in collaboration with Japanese companies among the government, research institutions, and local industries.
Direction of STI	· Key technology areas will continue to be emphasized. Amongst individual themes, sustainability, health, climate change, renewable energy, etc., are likely to receive attention. · In terms of content specific to Australia, there may be interest in gender equity and indigenous Australians.

(3) Interviews with Research Institutions (Conducted on March 17, 2023)

Questions	Summary of Responses
Challenges in STI	· Australia has a small population and has few researchers involved in research, so it is necessary to collaborate with renowned researchers from overseas when tackling problems.
Critical Technologies and Protections for Them	· Critical technologies are significant, but so are the priority areas of the NRF (National Reconstruction Fund), which is backed by funding. · Regarding the protection of critical technologies, the government has launched the UFIT (Task Force) and created “Guidelines to counter foreign interference in the Australian university sector.” Research institutions and funding agencies have their own security guidelines to measure foreign interference and conduct risk assessments. However, these are just guidelines. · Cyber-attacks on universities have actually occurred, and research institutions need to assess the risk that collaboration could bring. · In addition, there are security regulations specialized for critical technologies.
International Cooperation in STI Fields (Excluding Japan)	· Countries like the United States, the United Kingdom, Germany, and Canada are primarily chosen as partners for Australia due to cultural similarities, such as language, education systems, and international relations policies (like minded countries). Additionally, the long-term relationships they have built around trade, economy, defense, and politics are another factor. · China, which used to receive research funding from the Australian government, has now become one of the world’s leading research and development nations, and various joint research projects are being conducted with Australia. Although the political relationship between the two countries is less fixed, strong collaboration continues at the level of university researchers, and currently, there are no significant restrictions on joint research. · The Australian government plans to allocate funds to strengthen collaboration with like-minded countries. However, as mentioned above, it is unlikely that researchers’ interests will be highly influenced by politics, and collaboration is expected to continue in many fields (excluding critical technologies related to the military, etc.).
International Cooperation in STI Fields (Japan)	· Hydrogen technologies, agriculture, and healthcare (elderly medical care) are areas where Japan is recognized as a strong research partner. · Partnerships with Japan are mostly driven at lower levels (amongst universities and researchers) rather than at the government level. The collaboration between La Trobe University and Kyushu University is a prime example. Along with these low-level partnerships, there should also be an effort to strengthen and promote partnerships at the level of politics. · To improve and create STI research cooperation with Japan, focus should be on connecting domestic research institutions and universities in Australia with Japanese companies located in Australia. There are many areas in which Australian universities and Japanese companies have the potential to expand and deepen their research cooperation. The Australian government values connecting research outcomes with the industrial sector, and the presence of Japanese companies can be an important element in promoting STI cooperation between Japan and Australia. · To promote STI cooperation, it is necessary to identify the sweet spots where both countries can benefit from the targeted research. For this purpose, it is essential to identify each other’s priority areas and engage in discussions. In terms of fields, manufacturing and healthcare are important areas for both sides

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In addition to the sources cited in the individual footnotes, those referenced throughout the entire text are listed here.

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