**AMSI-MATRIX REPORT**

UPDATED — MAY 2024

# Research Investment and Expenditure into the **Mathematical Sciences**

MATRI

AMSI AUSTRALIAN MATHEMATICAL SCIENCES INSTITUTE

# 1. Executive summary

This report analyses research investment and expenditure in Australia to support research in the mathematical sciences over the period 2008–2023/24 using current publicly available data from the Australian Bureau of Statistics (ABS), the Australian Research Council (ARC) and the National Medical and Health Research Council (NHMRC).

Research investment and expenditure is largely facilitated through ARC and NHMRC grant schemes, and through business (BERD), government (GOVERD) and higher education expenditure (HERD) funding allocations. The main observations of this report are that:

1. As a percentage of total HERD expenditure, funding for the mathematical sciences plummeted from 1.86% in 2018 to 1.26% in 2022. Moreover, the portion of all university research classified at the basic end dropped from 41% to 35% over the same period (continuing a decline from 49% in 2008).

2. Against the background of the recent emphasis on research translation into commercialisable outcomes, university funding for research this last decade is already mostly flowing to applied research. Research in the mathematical sciences barely benefited from the funding surge earlier in the decade and further declined in 2022.

3. In terms of grant success, ARC investment in the schemes most relevant to the Mathematical Sciences (Field of Research (FoR) code 49), i.e. Discovery Projects, DECRAs and Future Fellowships is roughly on par with investment in other STEM disciplines [1]. However, overall success rates for all STEM disciplines is declining.

4. The ARC Linkage program is not well set up for supporting research in the Mathematical Sciences, only incidental grants have been awarded through this significant program.

5. The National Collaborative Research Infrastructure Strategy (NCRIS) completely ignores the mathematical sciences, with no identifiable project funded in the mathematical sciences despite a total investment of $1.38 billion under this scheme. The 2021 National Research Infrastructure Roadmap [2] remains completely silent about infrastructure needs for the mathematical sciences.

It is essential that research facilities in the Mathematical Sciences be recognised as part of the National Research Infrastructure, and be well funded alongside other basic research in support of Australia's long term prosperity.

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1 Other STEM in this report is defined as FoR codes 30, 31, 32, 34, 37, 40, 41, 42, 46, 49, and 51.

2 https://www.education.gov.au/national-research-infrastructure/2021-national-research-infrastructure-roadmap

# 2. Research Grants

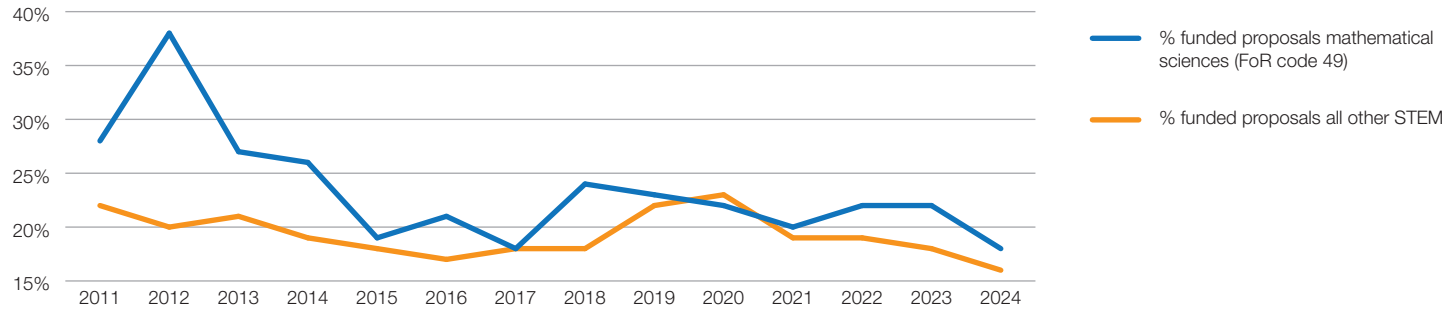
## Australian Research Council (Discovery)

The largest source of research grant funding for the Mathematical Sciences (FoR 49) is provided by the Discovery Scheme of the ARC, which is specifically targeted at supporting fundamental research. The Discovery Program supports research by individuals and teams, provides funding for research training and fosters career opportunities for Australian and international researchers.

### Discovery Projects

For projects commencing in 2024 the success rate equalled its lowest historical value of 2017 but was still slightly higher than that of other STEM codes (FoR 30, 31, 32, 34, 37, 40, 41, 42, 46, 49, and 51). As an aside we note that the percentage of submitted proposals in the mathematical sciences of all STEM submitted proposals has also remained remarkably constant during the period 2011-2024, hovering around 7.5%.

**Figure 1.** ARC Success Rates of Discovery Project Proposals 2011–2024

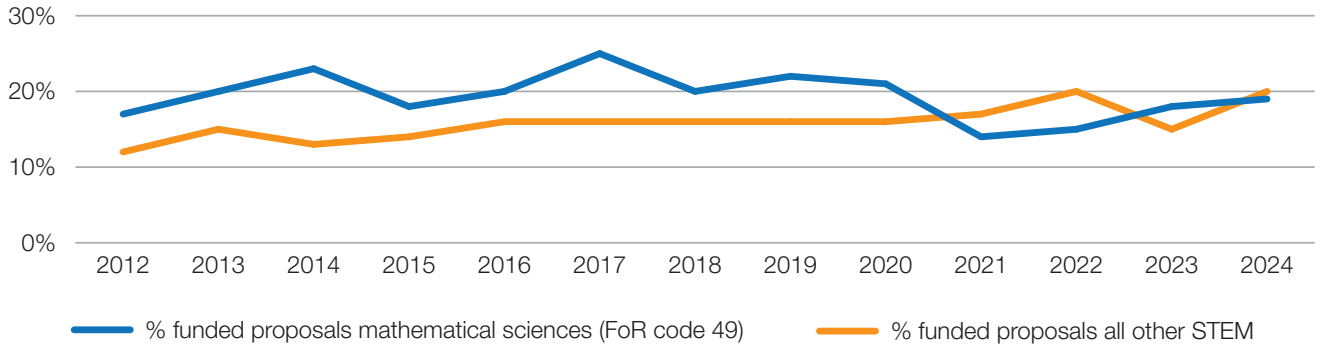



***Source**: ARC (2022–2024)*

## Discovery Early Career Awards (DECRA)

In 2023 and 2024 the success rate for DECRAs in the mathematical sciences picked up from its low point in 2021 and was slightly below that of other STEM codes in 2024. Both the number of successful DECRAs in FoR 49 starting in 2024 and the 2024 success rate have improved over recent years but are still slightly below long term averages. The number of successful DECRAs in other STEM disciplines on the other hand is slightly higher than its historical average.

**Figure 2.** ARC Success Rates of Discovery Early Career Researcher Award Proposals 2012–2024




***Source:*** *ARC (2022–2024)*

**Table 1.** Number of DECRAs Funded

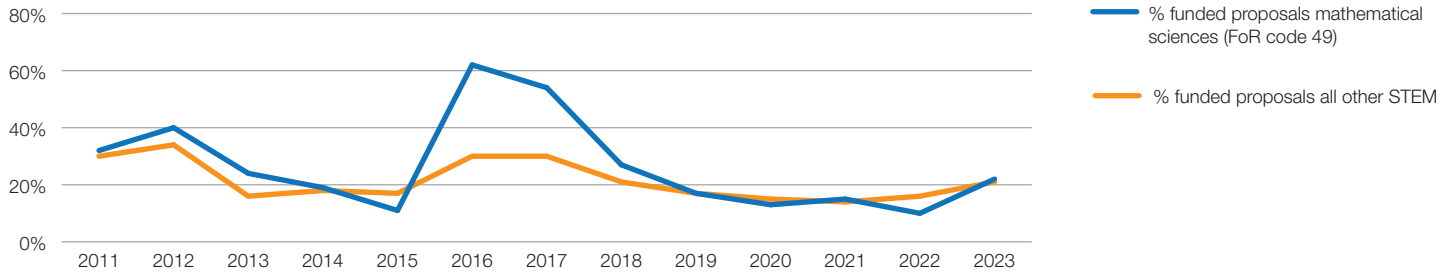
| Primary 4-digit FoR Code | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total (FoR 49 Math Sci)** | 0 | 15 | 12 | 14 | 12 | 14 | 13 | 10 | 12 | 14 | 8 | 5 | 7 | 9 |
| **Total (FoR Other STEM)** | 0 | 172 | 125 | 121 | 128 | 120 | 122 | 128 | 119 | 118 | 127 | 128 | 132 | 124 |

***Source:*** *ARC (2022–2024)*

# Future Fellowships

The success rate of Future Fellowships in 2023 improved, on par with other STEM disciplines. Since 2014 on average about five Future Fellowships are awarded each year to the Mathematical Sciences.

**Figure 3.** ARC Success Rates of Future Fellowship Proposals 2011–2023




***Source:*** *ARC (2022–2024)*

**Table 2.** Number of Future Fellowships Funded

| Primary 4-digit FoR Code | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total (FoR 49 Math Sci)** | 11 | 8 | 12 | 5 | 2 | 8 | 7 | 3 | 4 | 4 | 5 | 3 | 6 |
| **Total (FoR Other STEM)** | 140 | 145 | 137 | 101 | 34 | 64 | 57 | 78 | 65 | 64 | 60 | 65 | 64 |

***Source:*** *ARC (2022–2024)*

## Australian Laureate Fellowships

The success rate of Laureates in 2022 and 2023 was significantly higher than that for other STEM disciplines. On average about one Laureate Fellowship is awarded each year to the Mathematical Sciences, see Table 3.

**Table 3.** Number of Laureate Fellowships Funded

| Primary 4-digit FoR Code | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total (FoR 49 Math Sci)** | 3 | 2 | 2 | 1 | 2 | 0 | 3 | 0 | 1 | 1 | 1 | 2 | 2 |
| **Total (FoR Other STEM)** | 9 | 11 | 9 | 11 | 10 | 11 | 10 | 13 | 12 | 10 | 14 | 9 | 8 |

***Source:*** *ARC (2022–2024)*

# Australian Research Council (Linkage)

The ARC's Linkage funding schemes aim to encourage and extend cooperative approaches to research and improve the use of research outcomes by strengthening links within Australia's innovation system and with innovation systems internationally. Linkage promotes national and international research partnerships between researchers and business, industry, community organisations and other publicly funded research agencies. By supporting the development of partnerships, the ARC encourages the transfer of skills, knowledge and ideas as a basis for securing commercial and other benefits of research.

## Linkage Projects

Applications for funding under the Linkage Projects scheme must include at least one Partner Organisation. The success rate for Linkage Projects is generally much higher than for Discovery Projects, but the number of applications from the Mathematical Sciences in this scheme is very low. With the exception of 2016, the number of applications from the Mathematical Sciences to this scheme has been below ten and has dropped to below five since 2017. Consequently, the number of funded projects is also very low as can be seen from Table 4.

**Table 4.** Number of Linkage Projects Funded

| Primary 4-digit FoR Code | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total (FoR 49 Math Sci)** | 4 | 2 | 3 | 6 | 1 | 4 | 0 | 2 | 0 | 1 | 1 | 1 |
| **Total (FoR Other STEM)** | 264 | 237 | 200 | 178 | 179 | 245 | 95 | 91 | 111 | 133 | 138 | 96 |

***Source:*** *ARC (2022–2024)*

## Centres of Excellence

ARC Centres of Excellence are prestigious focal points of expertise through which high-quality researchers maintain and develop Australia's international standing in research areas of national priority. Through the ARC Centres of Excellence, significant collaborations occur between universities, publicly funded research organisations, other research bodies, governments and businesses in Australia and overseas, all to support outstanding research.

**Table 5.** Number of Centres of Excellence Funded

| Primary 4-digit FoR Code | 2011 | 2014 | 2017 | 2020 | 2023 |
|---|---|---|---|---|---|
| **Total (FoR 49 Math Sci)** | 0 | 1 | 0 | 0 | 1 |
| **Total (FoR Other STEM)** | 10 | 9 | 7 | 6 | 7 |

***Source:*** *ARC (2022–2024)*

The ARC Centre of Excellence for the Mathematical Analysis of Cellular Systems (MACSYS) commenced in 2023. The ARC Centre of Excellence for Mathematical and Statistical Frontiers (ACEMS) commenced in 2014 and finished at the end of 2021. The ARC Centre of Excellence for Mathematics and Statistics of Complex Systems (MASCOS) was established in 2003. Before that, the Centre for Mathematical Analysis (CMA) was established in 1982 under the (then) Commonwealth Program for the Promotion of Excellence in Research. Both fall outside the reference period of this report, but are the only other known CoEs classified under Mathematical Sciences.

## Industrial Transformation Training Centres

The Industrial Transformation Training Centres scheme fosters close partnerships between university-based researchers and other research end-users to provide innovative Higher Degree by Research (HDR) and postdoctoral training, for end-user focused research industries that are vital to Australia's future.

**Table 6.** Number of Industrial Transformation Training Centres Funded

| Primary 4-digit FoR Code | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total (FoR 49 Math Sci)** | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 |
| **Total (FoR Other STEM)** | 4 | 6 | 5 | 6 | 9 | 7 | 5 | 4 | 6 | 5 | 8 |

***Source:*** *ARC (2022–2024)*

The ARC Industrial Transformation Training Centre in Data Analytics for Resources and Environments (DARE) commenced in 2019. The ARC Industrial Transformation Training Centre in Optimisation Technologies, Integrated Methodologies, and Applications (OPTIMA) commenced in 2020.

## Linkage Infrastructure, Equipment and Facilities (LIEF)

The Linkage Infrastructure, Equipment and Facilities scheme provides funding for research infrastructure, equipment and facilities to eligible organisations. The scheme enables researchers to participate in cooperative initiatives so that expensive research infrastructure, equipment and facilities can be shared between higher education organisations and also with industry. The scheme also fosters collaboration through its support of the cooperative use of international or national research facilities. While over the last decade some LIEF grants have been awarded with a subsidiary Mathematical Sciences component, to date only one LIEF grant has been awarded with a primary FoR 49 code, to improve access to MATRIX.

**Table 7.** Number of Linkage Infrastructure, Equipment and Facilities Proposals Funded

| Primary 4-digit FoR Code | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021 | 2022 | 2023 | 2024 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total (FoR 49 Math Sci)** | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| **Total (FoR Other STEM)** | 73 | 72 | 65 | 57 | 64 | 51 | 43 | 46 | 31 | 45 | 42 | 42 | 41 | 34 |

***Source:*** *ARC (2022–2024)*

# National Health and Medical Research Council (NHMRC)

While very few NHMRC grants were awarded to mathematical scientists in the period 2013-2023, there are some which have a mathematical sciences component. In 2019 a new grant program was introduced, including NHMRC Investigator, Ideas and Synergy grant schemes. Mathematical Sciences related keywords that were chosen in NHMRC grant applications between 2013-2023 included:

- Applied Statistics,
- Biostatistics,
- Markov chain Monte Carlo,
- Mathematical modelling,
- Multivariate statistics,
- Statistical genetics,
- Statistics.

## Project Grants

NHMRC Project Grants was the NHMRC's previous flagship funding program, before the introduction of the new grant program in 2019. Project Grants supported the investigation of new research ideas, and were between one and five years in length.

**Table 8.** NHMRC Project Grants with Mathematical Sciences Keywords

| NHMRC Project Grants | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| **At Least One Math. Sci. Keyword** | 8 | 8 | 9 | 5 | 5 | 9 |
| **A Primary Math. Sci. Keyword** | 2 | 2 | 3 | 1 | 1 | 2 |

***Source:*** *NHMRC (2013–2023)*

## Early Career Fellowships

NHMRC Early Career Fellowships provided opportunities for Australian researchers to undertake advanced training in health and medical research either in Australia or overseas, before they were included in the new grant program. A major objective of the scheme was to foster career development at the postdoctoral level by encouraging the beneficial experience of a different research environment.

**Table 9.** NHMRC Early Career Fellowships with Mathematical Sciences Keywords

| NHMRC Early Career Fellowships | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| At Least One Math. Sci. Keyword | 4 | 3 | 4 | 4 | 5 | 4 |
| A Primary Math. Sci. Keyword | 0 | 0 | 1 | 0 | 0 | 0 |

***Source:*** *NHMRC (2013–2023)*

## Career Development Fellowships

NHMRC Career Development Fellowships were highly competitive, four year Fellowships that recognised and provided support for the most outstanding early to mid-career health and medical researchers.

**Table 10.** NHMRC Career Development Fellowships with Mathematical Sciences Keywords

| NHMRC Career Development Fellowships | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| At Least One Math. Sci. Keyword | 2 | 2 | 3 | 3 | 1 | 1 |
| A Primary Math. Sci. Keyword | 0 | 0 | 0 | 1 | 0 | 1 |

***Source:*** *NHMRC (2013–2023)*

## Research Fellowships

NHMRC Research Fellowships were prestigious and highly competitive awards for high performing researchers, before the introduction of the new grant program. Research Fellowships were open to all researchers in Australia who had a sustained track record of significant and quality research output as judged relative to opportunity.

**Table 11.** NHMRC Research Fellowships with Mathematical Sciences Keywords

| NHMRC Research Fellowship | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|
| At Least One Math. Sci. Keyword | 0 | 6 | 2 | 1 | 2 | 2 |
| A Primary Math. Sci. Keyword | 0 | 0 | 1 | 1 | 0 | 0 |

***Source:*** *NHMRC (2013–2023)*

## Ideas Grants

The objective of the Ideas Grant scheme is to support innovative research projects addressing a specific question(s). The scheme provides particular opportunities for early and mid-career researchers. It is expected that the awardee will have the capability to lead the team in achieving the project aims.

**Table 12.** NHMRC Ideas Grants with Mathematical Sciences Keywords

| NHMRC Ideas Grants | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|
| At Least One Math. Sci. Keyword | 9 | 10 | 2 | 4 | 1 |
| A Primary Math. Sci. Keyword | 1 | 1 | 0 | 1 | 0 |

***Source:*** *NHMRC (2013–2023)*

## Investigator Grants

Investigator Grants consolidate separate fellowship and research support into one grant scheme that provides the highest-performing researchers at all career stages with funding for their salary (if required) and a significant research support package. These grants provide the investigator with flexibility to pursue important new research directions as they arise and to form collaborations as needed, rather than being restricted to the scope of a specific research project.

**Table 13.** NHMRC Investigator Grants with Mathematical Sciences Keywords

| NHMRC Investigator Grants | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|
| **At Least One Math. Sci. Keyword** | 28 | 7 | 8 | 6 | 14 |
| **A Primary Math. Sci. Keyword** | 5 | 1 | 3 | 2 | 7 |

***Source:*** *NHMRC (2013–2023)*

# 3. Business, Government and Higher Education Expenditure on Research and Development

The main measures for R&D expenditure in Australia are collected every two years by the Australian Bureau of Statistics (ABS). Key measures of R&D expenditure are defined as follows.

- Business Expenditure on Research and Development (BERD) is expenditure and human resources devoted to R&D carried out by businesses in Australia.
- Government Expenditure on Research and Development (GOVERD) is expenditure and human resources devoted to R&D carried out by Commonwealth, state and territory governments.
- Private Non-Profit Expenditure on Research and Development (PNPERD) is expenditure and human resources devoted to R&D carried out by private non-profit organisations.
- Higher Education Expenditure on Research and Development (HERD) is expenditure and human resources devoted to R&D undertaken by Australian higher education institutions.

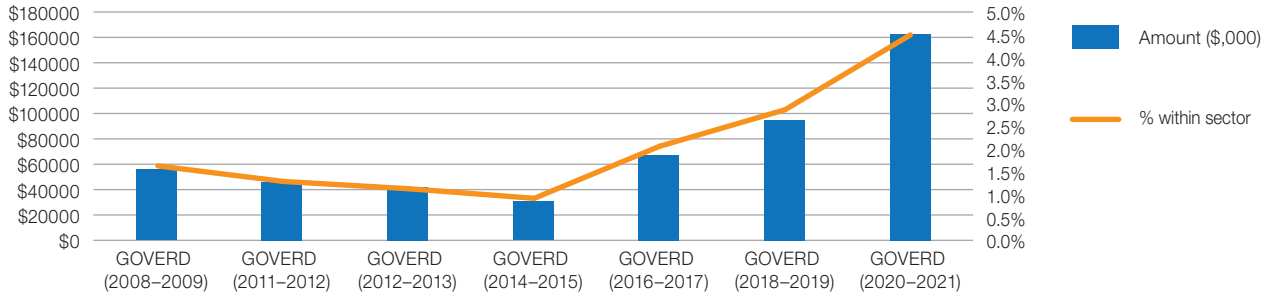
Note that these measures of R&D are expenditure measures, not measures of the source of funds. This means that GOVERD/PNPERD and HERD are mutually exclusive. Traditionally HERD is largely sourced by government funds, with block grants from the Department of Education, Skills and Employment (DESE) making up around one-third of that income.

PNPERD expenditure to research in the Mathematical Sciences is essentially non-existent. The majority of PNPERD (91%) is directed to the Socio-economic Objective of Health ($1,274 million) in 2020-21, followed by Education and Training ($38 million or 3%).

# Government Expenditure on Research and Development (GOVERD)

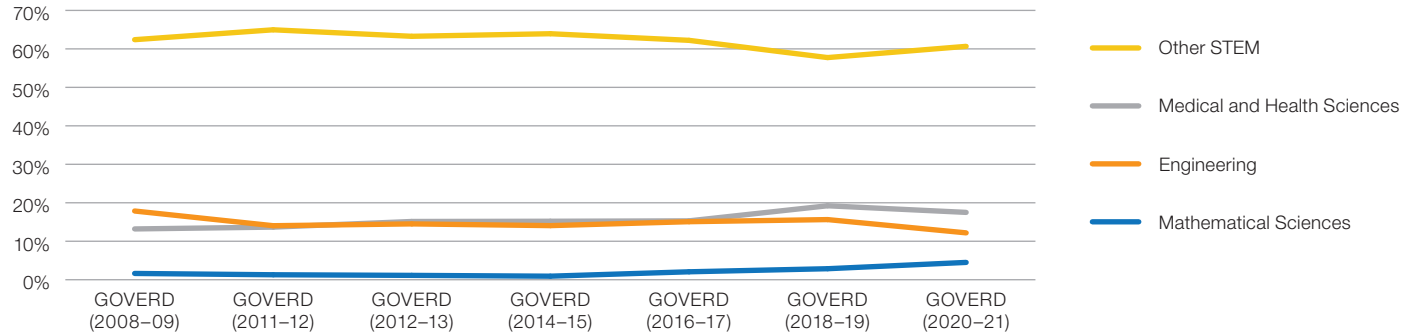
GOVERD expenditure includes expenditure and human resources devoted to Research and Experimental Development (R&D) carried out by governments.

**Figure 4.** Total $ and % Government Expenditure on R&D in the Mathematical Sciences




***Source:*** *ABS (2022)*

**Figure 5.** % of Total Government Expenditure on R&D by Field (2008–2021)



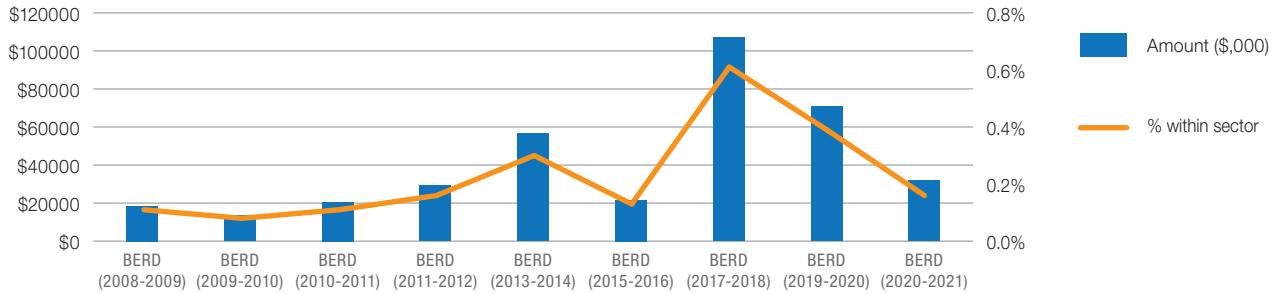

***Source:*** *ABS (2022)*

**Comment**: As a percentage of total expenditure, GOVERD expenditure to the Mathematical Sciences increased from a minimum of 0.92% in 2014/15 to a maximum of 4.50% in 2020/21.

# Business Expenditure on Research and Development (BERD)

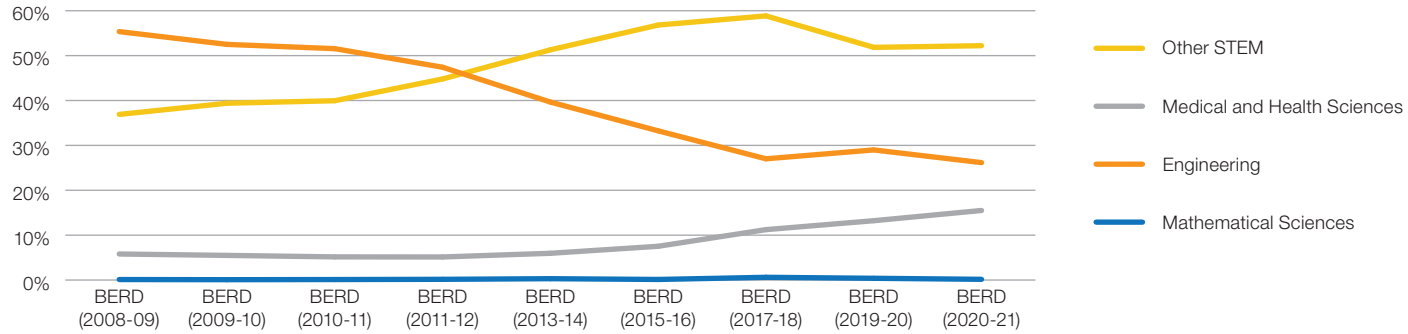
Business expenditure includes expenditure and human resources devoted to Research and Experimental Development (R&D) carried out by businesses in Australia.

**Figure 6.** Total $ and % Business Expenditure on R&D in the Mathematical Sciences




***Source:*** *ABS (2023)*

**Figure 7.** % of Total Business Expenditure on R&D by Field of Research and Development




***Source:*** *ABS (2023)*

**Comment**: As a percentage of total expenditure, BERD expenditure to the Mathematical Sciences fluctuated between a minimum of 0.08% in 2009/10 and a maximum of 0.61% in 2017/18, dropping to 0.16% in 2021/22.

# Higher Education Expenditure on Research and Development (HERD)

Higher Education expenditure includes funding provided by Higher Education institutions (mostly universities) to perform research and experimental development. Common funding sources to fund research are general university funds, state, local and Commonwealth funding such as block grants, as well as funding provided by business and donations and bequests.

As identified in a 2020 report by Frank Larkins[3], overall HERD expenditure increased significantly in the decade to 2018 using discretionary income resulting from exceptional growth in annual university operating revenues. Despite a decline of the percentage of total annual operating expenditure devoted to R&D, a new landmark was achieved in 2018 with universities collectively using more discretionary income to fund research and research training programs than the total funds obtained from external competitive sources. In 2022 the overall HERD expenditure increased somewhat in real terms but mathematical sciences research received $74.5 million less in real terms compared to 2018. Proportionally HERD expenditure allocated to the discipline has continued to decline significantly, from 1.86% in 2018 to 1.26% in 2022.

A key conclusion from the Larkins report identifies that `since 2008 there has been a significant shift in the type of research reportedly undertaken by universities from basic and strategic basic research to applied research and experimental development, partly because of the 30% decline in business R&D as a percent of GDP. In 2022 only 35% of all university research was classified at the basic end, down from 49% in 2008. There are serious consequences for knowledge creation and Australia's national innovation effort if this decline is not reversed.'

In 2022 the proportion of funding to basic research declined even further, to 35% - down from 41% in 2018.

**Table 14.** HERD Expenditure to types of research activities – for all Fields of Research (chain volume measure applied)

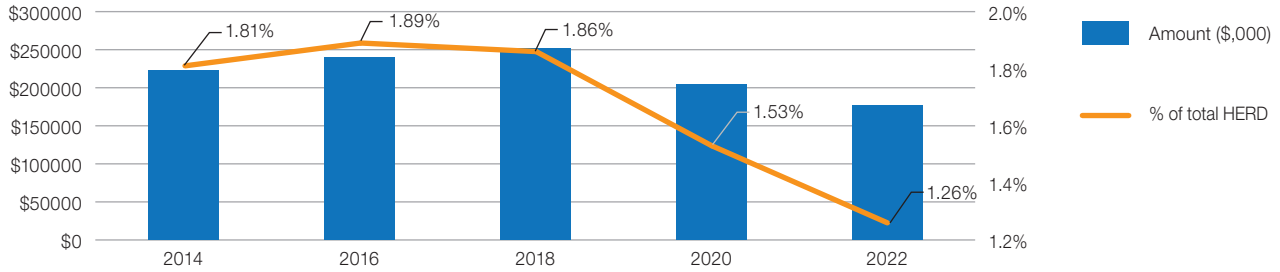
| | 2014 | 2016 | 2018 | 2020 | 2022 |
|---|---|---|---|---|---|
| **Total (Chain Volume Measures) $m** | $12,315 | $12,701 | $13,534 | $13,359 | $13,990 |

*Source: ABS (2024)*

**Comment**: Total HERD expenditure*, in real terms, increased by 14% between 2012 and 2022.

3 Frank Larkins, Strong research performances by Australian universities depend increasingly on unsustainable internal discretionary funding, Melbourne Centre for the Study of Higher Education, 2020.

**Figure 8.** HERD Expenditure Mathematical Sciences 2012-2022 (chain volume measure applied*)

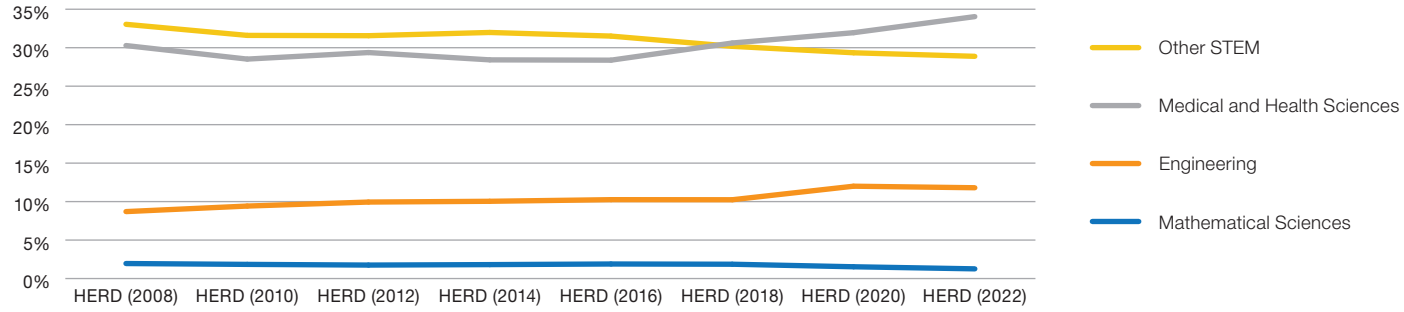



***Source:*** *ABS (2024)*

**Comment**: As a percentage of total HERD expenditure funding for the Mathematical Sciences has fluctuated between 1.95% in 2008 and 1.75% in 2012 and in 2018 stood at 1.86% of total HERD expenditure before falling to its lowest proportion (1.26%) ever in 2022.

*Chain Volume Measure (CVM): Current price values re-expressed in (i.e. based on) the prices of the previous year and linked together to form a continuous time series. The current prices values are referenced to 2022.

**Figure 9.** % of Total Higher Education Expenditure on R&D by Field




***Source:*** *ABS (2024)*

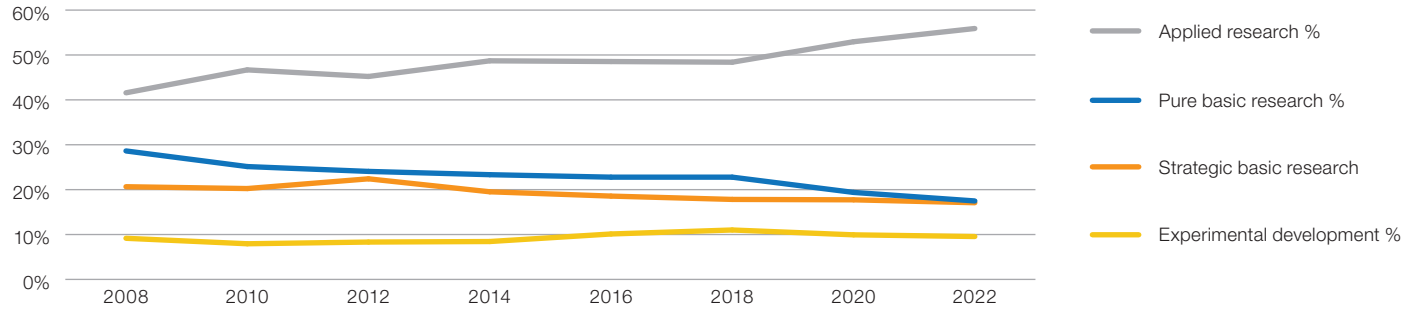
## HERD Expenditure to types of research activities—for all Fields of Research

**Comments**:

- When compared to 2012, in 2022 HERD expenditure amounts in real terms, had decreased by 6.6% for pure basic research, and by 2% for strategic basic research. In the same period HERD expenditure for applied research increased by 59%, and for experimental development by 47%. Compared to 2020, HERD expenditure for applied research increased in 2022 by 13.5%. All other types of research expenditure remained within a 3% change.

- As a percentage of total HERD expenditure, the proportions of funding spent on pure basic research and strategic basic research decreased between 2012 and 2022. The proportion of HERD expenditure for applied research and experimental development increased – see graph below.

**Figure 10.** Percentage HERD Expenditure by Type of Activity 2008-2022 – All Fields of Research




***Source:*** *ABS (2024)*

# 4. National Collaborative Research Infrastructure Strategy (NCRIS)

NCRIS is an initiative of the Australian Government aimed at maximising investment to ensure researchers have access to advanced national research infrastructure.

Through the NCRIS program, significant investments have been made in STEM projects, building on the government's commitment under the National Innovation and Science Agenda (NISA). A total of $393.3 million was invested in NRI projects as part of the NCRIS 2018 Funding Round, in addition to $178.9 million already invested in three projects. The NCRIS 2020 Funding Round invested $157.4 million in NRI projects, increasing to $650 million invested through the NCRIS 2023 Funding Round.

**NCRIS projects are not categorised under Fields of Research (FoR) codes but no projects for the mathematical sciences were identified despite an overall $1.38 billion investment under this scheme.**

Currently funded projects through the NCRIS Strategy: https://www.education.gov.au/national-research-infrastructure/funded-research-infrastructure-projects

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