

TE PŪRONGO, RANGAHAU PŪTAIAO ME TE AUAHATANGA — 2021

THE RESEARCH, SCIENCE AND INNOVATION REPORT — 2021

Te Whakatutukinga o te Pūnaha Rangahau Pūtaiao me te Auahatanga o Aotearoa
Performance of the New Zealand RSI system



MINISTRY OF BUSINESS,
INNOVATION & EMPLOYMENT
HĪKINA WHAKATUTUKI



MBIE develops and delivers policy, services, advice and regulation to support economic growth and the prosperity and wellbeing of New Zealanders. MBIE combines the former Ministries of Economic Development, Science + Innovation, and the Departments of Labour, and Building and Housing.

More information

Information, examples and answers to your questions about the topics covered here can be found on our website, www.mbie.govt.nz, or by calling us free on 0800 20 90 20.

For more detailed findings, refer to the full report that can be found here: www.mbie.govt.nz/science-and-technology/science-and-innovation/research-and-data/sector-data/.

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Performance of the New Zealand RSI system

Kupu whakataki

Foreword

Tēnā koutou katoa

The events of 2020 and 2021 have shown the importance of a strong research system. I am particularly grateful to our research sector for stepping up to the challenges of the COVID-19 pandemic. Information provided by our researchers protected the health and wellbeing of our team of five million by informing our response. We are continuing to take an evidence-based approach to continue our good work.

The government's key priorities are keeping New Zealanders safe from global challenges such as COVID-19, accelerating our economic recovery and laying the foundations for a better future. Research, science and innovation plays an important part in achieving this, which is why we need to understand how the system is performing so we can make good investment decisions and develop effective policy.

This report shows our system performs well for the level of investment we make, particularly in international co-publication rates. Ensuring our system keeps pace with other small advanced economies remains challenging. Key to this will be ensuring our system is able to quickly and easily respond to changing needs, and that our research workforce can grow the diversity and breadth of perspective needed to generate new ideas, skills and knowledge. This includes continuing our investments to support mātauranga Māori and ensuring New Zealand has a place at the frontier of expanding knowledge and technological developments.



Hon Dr Megan Woods
Minister of Research, Science and Innovation
October 2021

I am proud that we have been able to support continued investment in research by industry through the Research and Development Loan Scheme and more widely through the COVID Innovation Acceleration Fund. The effects of these investments are yet to be seen in the data, but I have no doubt that they will have supported excellent, world-class research activities.

This year is the first time we have designed the biennial Research, Science and Innovation System Performance Report as an interactive digital tool, alongside hard copy. The new digital format allows users to undertake more granular analysis of the source data, which we hope will lead to additional insights. We welcome feedback as we continue to develop this tool.

I am looking forward to working with the sector and seeing how the system evolves over the next 2 years to better meet our needs and address our greatest challenges.

Nāku iti noa, nā



Kupu whakataki

Introduction

Aotearoa New Zealand invests in research, science and innovation because they are fundamental for improving our economic, environmental, social and cultural wellbeing. Evidence from OECD countries shows that new knowledge and innovation are essential for long-term economic growth and social progress.

In 2017 the government set a target of raising economy-wide investment in research and development to 2 per cent of gross domestic product (GDP) over 10 years. Investment in research, science and innovation is a critical part of achieving this goal.

Many people and institutions contribute to research, science and innovation in New Zealand. This report can be used as a resource for those who want to know more about the system and its performance. In particular, the report aims to: increase transparency and provide a central, reliable source of data about the system; report on progress towards government goals – highlighting strengths, weaknesses and opportunities; and stimulate discussion among policy makers, funders, researchers and all those who benefit from the research and innovation.

Data and commentary are presented in parallel to show how the system is performing, based on the skills, funding and knowledge produced as well as the impacts for New Zealand. Core indicators from the 2018 Research, Science and Innovation System Performance Report have been updated with new data and analysis. Case studies, detail panels and infographics

showcase examples and highlight particular topics. The important voice of Vision Mātauranga and its benefits to the system are woven throughout.

In late January 2020 the world began to respond to a growing threat from the COVID-19 virus, and the subsequent pandemic affected many aspects of our daily lives. The research, science and innovation sector in New Zealand and worldwide has responded with funding, research activities, expert advice and innovation to meet the many challenges to life and livelihoods. This report acknowledges the disruption caused by the pandemic and the responsiveness of the sector in such extraordinary times. The sector's contribution to this country's COVID-19 response is highlighted throughout the report.

This report is the third in a series about research, science and innovation in New Zealand – the previous reports were in 2016 and 2018. This is the first time it has been published in a digital format.

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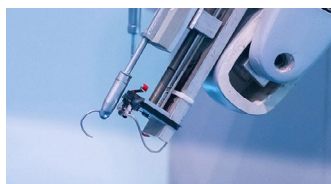
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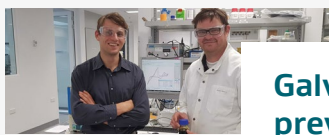
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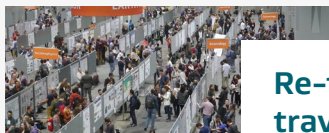
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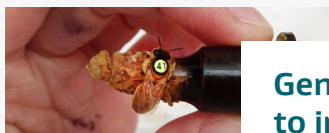
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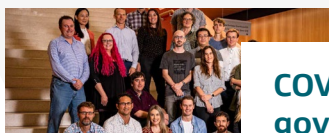
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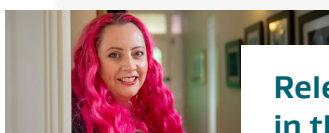
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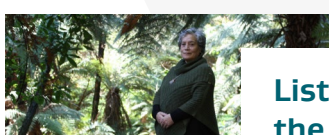
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CHAPTER 1

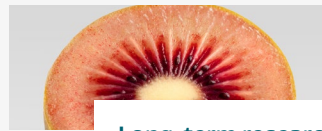
Te whakatipu rangahau me te whakawhanake

Growing research and development

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Kupu whakataki Introduction

This chapter explores New Zealand's investment in R&D. It presents total research expenditure and trends, research funding and detail on funding by different sources.

Note that throughout this report 'R&D expenditure' refers to the amount of money attributed to R&D activity for a given sector.

This chapter does not reflect the impacts of COVID-19. The Stats NZ research and development survey data reflects financial years, and for most organisations the 2020

financial year ended on 31 March 2020. The figures presented in this chapter are for financial years and not calendar years. For most organisations the 2020 financial year ended on 31 March 2020, so data relates largely to the period before any impact of COVID-19.

Ngā miramira wāhanga Chapter highlights

Between 2010 and 2020, total R&D expenditure increased by **90 per cent.**

Although R&D expenditure increased across business, government and higher education sectors, it was mainly driven by substantial increases in business R&D.

In 2020, R&D was primarily undertaken by government, business and higher education sectors to benefit the primary industries, manufacturing, health, information and communication services, and the environment industries.

New Zealand generates more publications per dollar invested in research than other small advanced economies.

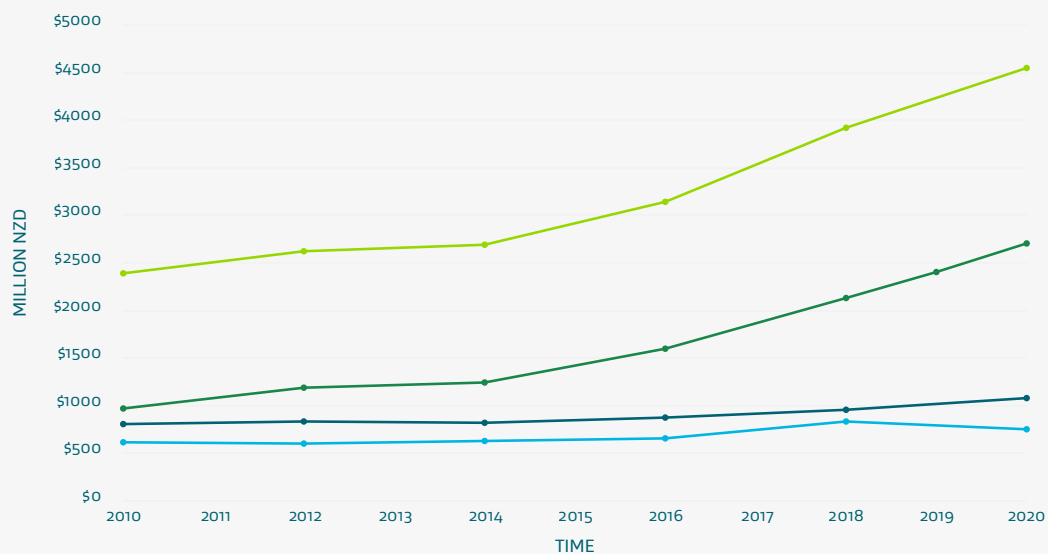
1.1 Ngā whakapaunga R&D

Expenditure on R&D

10

FIGURE 1
Total R&D expenditure by sector

Total expenditure on R&D is used as a measure of R&D activity in New Zealand. It increased by 90 per cent between 2010 and 2020. Although expenditure on R&D has increased across all sectors (ie government, higher education and business), the greatest increase was in the business sector. Business contributed 60 per cent of the total expenditure in 2020 – up from 41 per cent in 2010.



Data source:

Stats NZ research and development survey See page 101

Data for total R&D expenditure comes from the [research and development survey](#)¹. Spending by businesses, universities, Crown research institutes (CRIs) and government agencies is included. 2019 data includes business sector R&D only. Dollar values are actual amounts.

Sector totals

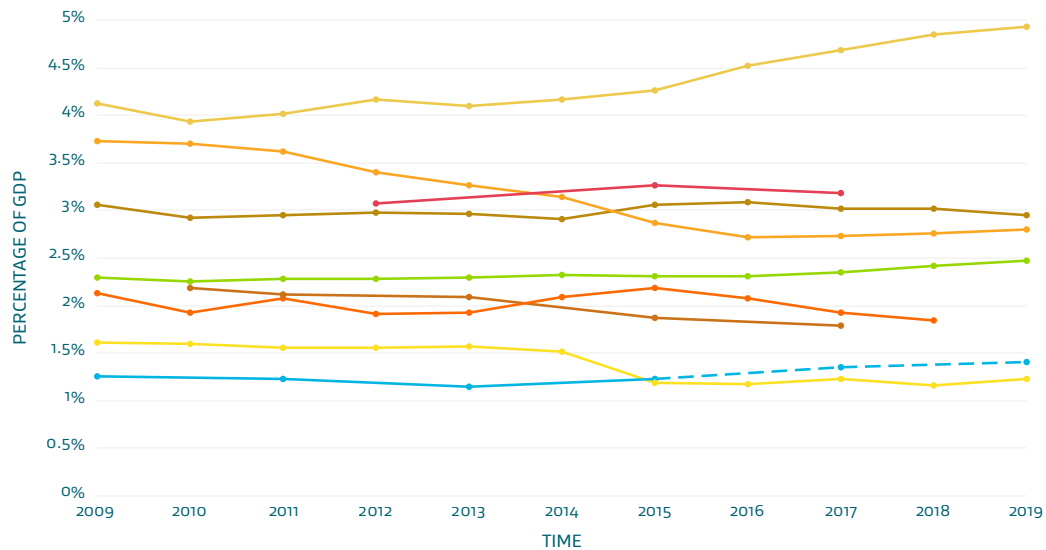
- All sectors total
- Business sectors total
- Higher education total
- Government sectors total

1. www.stats.govt.nz/information-releases/research-and-development-survey-2020

FIGURE 2
Total expenditure on R&D as a percentage of GDP

As a proportion of GDP, total R&D expenditure in New Zealand is low compared with Australia, the OECD and other small advanced economies (see [Small Advanced Economy Initiative](#)²).

In 2019, New Zealand's total R&D expenditure as a proportion of GDP was 1.41 per cent, up from 1.25 per cent in 2009.



Data source:

OECD main science and technology indicators See page 101

Stats NZ research and development survey See page 101

The OECD offsets New Zealand R&D survey data by 1 year for comparative purposes (ie 2018 Stats NZ R&D data is shown as 2017 OECD data). New Zealand's R&D expenditure was weighted by GDP using OECD data to enable comparisons with other countries. Expenditure data is in constant prices. National currency data was converted to USD using the [purchasing power parity](#)³ series from the OECD National Accounts Division. See [further information](#)⁴. Data for 2017 was recalculated based on revised 2020 Stats NZ R&D survey data. Data for 2019 was approximated based on 2020 Stats NZ R&D survey data. The dashed line leads through the approximated values.

Country/region

- Israel
- Switzerland
- Denmark
- Finland
- OECD - Total
- Singapore
- Australia
- New Zealand
- Ireland

COVID-19 research activity and database

A July 2020 analysis of peer-reviewed publications related to COVID-19 showed that most New Zealand research was in public health and clinical science. Most non-medical research was focussed on the social effects of the pandemic including tourism, psychology and policy. About 10 per cent of researchers had published in completely new research fields.

A central database of COVID-19 research and funding was set up by the New Zealand Research Information System team at MBIE to support researchers to share ideas and work together.

[Read more and access the database](#)⁵

2. www.smalladvancedeconomies.org 3. www.oecd.org/sdd/prices-ppp/ 4. www.oecd.org/sti/inno/MSTI_documentation_e.pdf 5. www.mbie.govt.nz/science-and-technology/science-and-innovation/research-and-data/nzris/covid-19-research-database/

FIGURE 3
R&D expenditure by sector and purpose of research

Expenditure on R&D is undertaken in the business, government and higher education sectors. The amounts vary and a wide range of industries benefit.

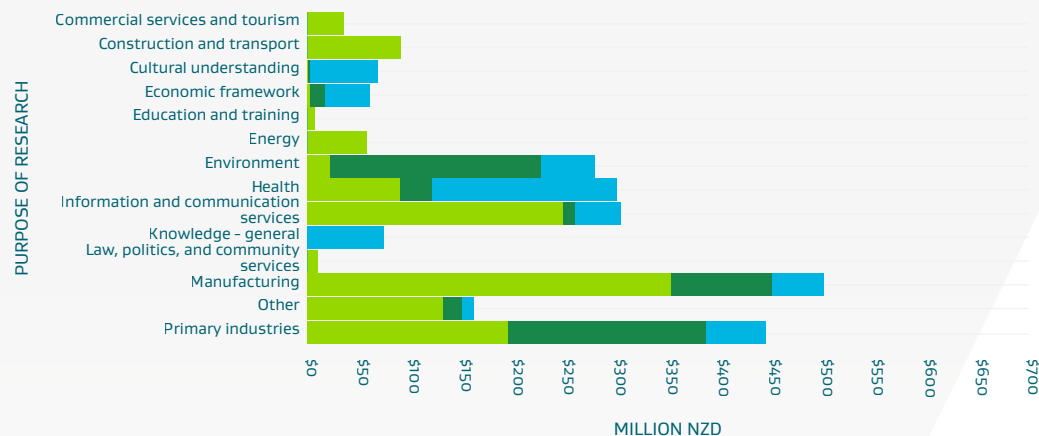
Government R&D is directed towards health, environment, primary industries and manufacturing. These areas accounted for about 90 per cent of all government expenditure on R&D in 2020.

Business R&D expenditure in 2020 was targeted towards manufacturing, primary industries, health, and information and communication services. This accounted for 70 per cent of overall business R&D expenditure.

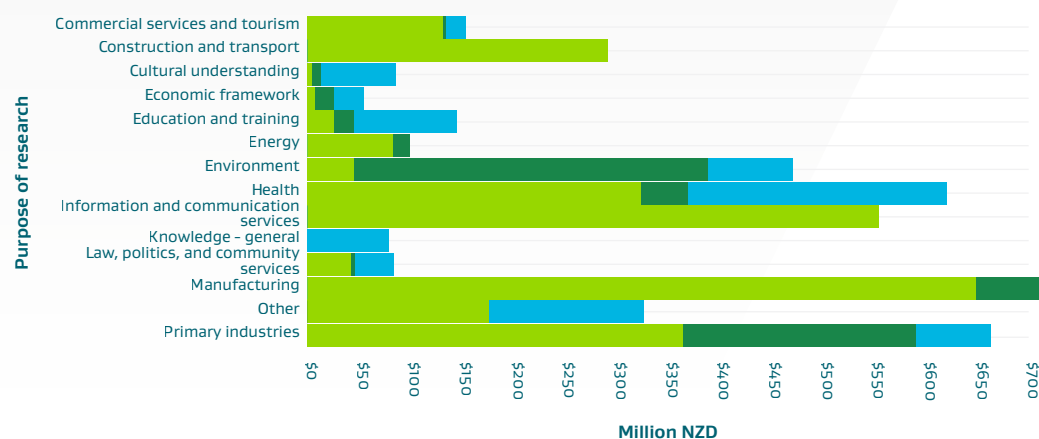
Higher education R&D expenditure in 2020 was focussed on health, education and training, general knowledge, cultural understanding and the environment. These areas comprised half (54%) of all higher education expenditure on R&D in 2020.

In 2020, almost three quarters (73%) of all R&D expenditure of benefit to the environment was government-funded. In the same year, the business sector undertook all of the R&D for construction and transport and information and communication services. The business sector also undertook most of the R&D for commercial services and tourism (86%). In contrast, the higher education sector mostly undertook R&D to benefit cultural understanding (84%) and education and training (68%).

2014



2020



Data source:

Stats NZ research and development survey See page 101

Data for total R&D expenditure comes from the [research and development survey](#)⁶. Dollar values are actual amounts. Purpose relates to the sector that will ultimately benefit from the R&D, not the nature of the R&D itself.

Sector totals

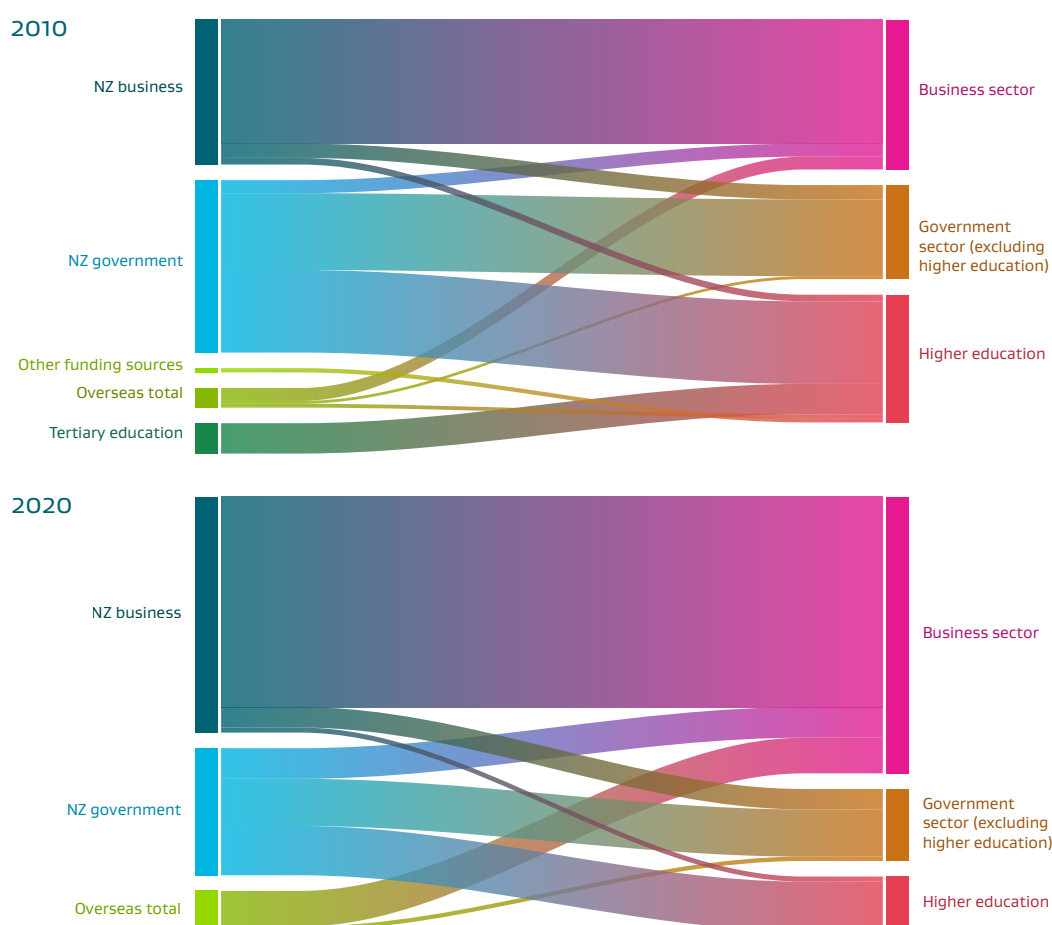
- Business sector
- Government sector (excluding higher education)
- Higher education

1.2 Tuku pūtea R&D R&D funding

FIGURE 4
R&D funding by source and sector of recipient

Total funding for R&D grew by nearly 80 per cent between 2010 and 2020. Most of the increase was in business funding. Since 2016, business has been the largest source of funding for R&D in New Zealand.

Between 2010 and 2020, the government was the largest funder of R&D, with funds primarily targeted towards the higher education and government research sectors. Funding from non-government sources (business and overseas) increased from 43 to 58 per cent of the total during this period.



Data source:
Stats NZ research and development survey See page 101

Data for funding (in million NZD) sources comes from the [research and development survey](#)⁶. The figures include R&D activity by businesses, government agencies, universities and CRIs. These totals may differ from funding totals used in reporting R&D expenditure.

6. www.stats.govt.nz/information-releases/research-and-development-survey-2020

1.3 Tuku pūtea tūmatanui ki R&D Public funding of R&D

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FIGURE 5
Total public R&D funding

Public funding for R&D rose by 75 per cent between 2010 and 2020. Although R&D tax incentives and some grant funding (such as project grants) are targeted to businesses, these are not tied to specific socioeconomic outcomes and are not included in government budget allocations for R&D. Public funding as a percentage of GDP is also presented in this figure for the same time period.

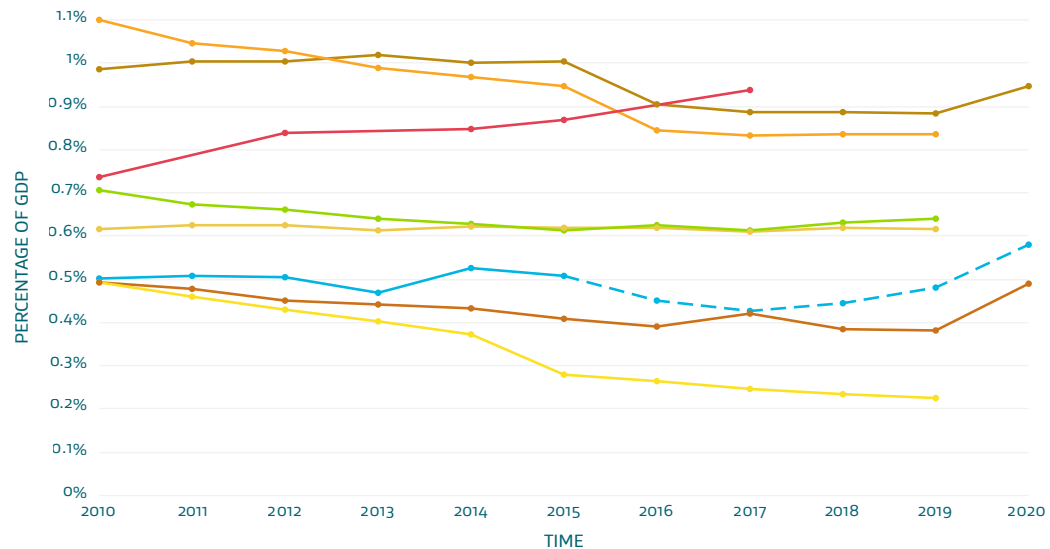


Data source:
[New Zealand government budget allocation for research and development](#)
See page 100

Public funding is the total amount of government budget allocated for R&D. Dollar values are actual amounts. This figure does not include appropriations from the R&D Tax Incentive. Data from 2016–2020 is from Treasury appropriations in which the amounts of public funding are determined using a revised MBIE calculation method. Public funding as a percentage of GDP is shown in a second figure.

FIGURE 6
Public R&D funding as a percentage of GDP compared with other small advanced economies

Public funding of R&D in New Zealand is low compared with other small advanced economies, but has increased by 0.15 per cent since 2017. This trend in R&D growth as a percentage of GDP is also seen in countries such as Australia and Denmark.



Data source:
[New Zealand government budget allocation for research and development](#) See page 100
[OECD research and development statistics](#) See page 101
[OECD main science and technology indicators](#) See page 101

Country/region

- Denmark
- Switzerland
- Finland
- OECD - Total
- Israel
- New Zealand
- Australia
- Ireland

Public funding is the total amount of government budget allocated to R&D. The OECD offsets data from the New Zealand R&D survey by 1 year for comparative purposes (ie 2018 Stats NZ R&D data is shown as 2017 OECD data). The allocations are measured in constant USD (prices and purchasing power parities). New Zealand public funding data from 2016-2020 is from MBIE estimates that were recalculated. New Zealand's public funding was weighted by GDP using OECD data to enable comparisons with other countries. National currency data was converted to USD using the [purchasing power parity](#)⁷ series from the OECD National Accounts Division. See [further information](#)⁸.

Advanced Energy Technology Platform

Developing technologies to transform the way energy is produced, used, managed and stored

Advanced energy technology research is essential to improve energy security and access, and to reduce pressure on the environment and emissions of greenhouse gases. The Government is investing \$50 million over 7 years to ensure New Zealand is at the forefront of energy technology research and innovation. The first three funded programmes are:

- high power electric motors for large-scale transport – developing new component technologies for future electric aircraft
- architecture of the future low-carbon, resilient, electrical power system – how high levels of direct current can be efficiently integrated into the alternating current electricity grid
- Ahuora: delivering sustainable industry through smart process heat decarbonisation – developing critical technology for decarbonising the process heat sector.

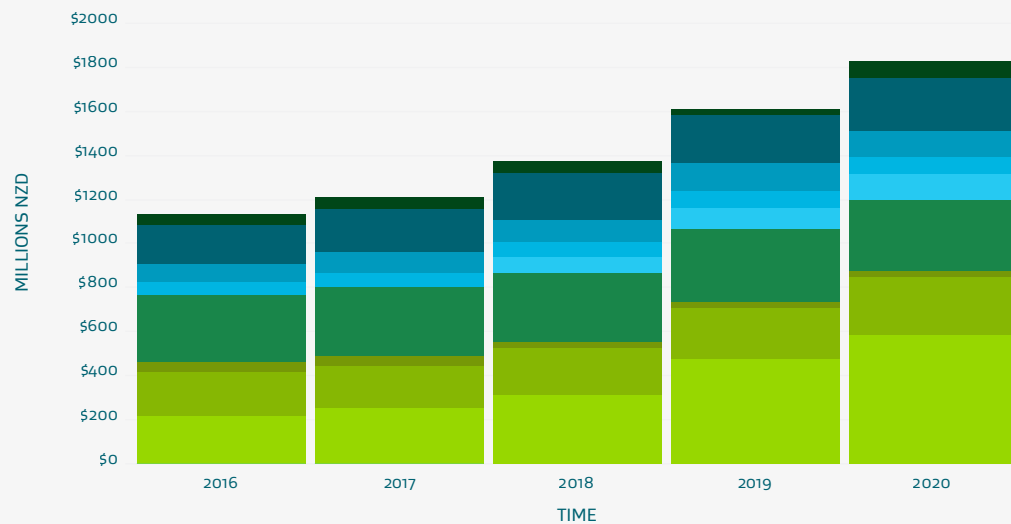
[Read more](#)⁹

FIGURE 7 Public funding by mechanism

Public funding of R&D is provided through a number of mechanisms, like the Endeavour Fund and [Centres of Research Excellence funding](#)¹⁰.

The largest increases in funding have been directed towards supporting industry research, including investment through the [Strategic Science Investment Fund](#)¹¹.

This graph does not include the [Research and Development Tax Incentive](#)¹² that was introduced in April 2019.



Data source:

[Budget allocations in research and development by funding mechanism](#) See page 100

Public R&D funding mechanisms for 2016–2020. Dollar values are actual amounts. The structure of vote appropriations was changed in 2016 so data may not be comparable to previous years.

Funds

- Centres of Research Excellence
- Endeavour Fund
- Health Research Fund
- Marsden Fund
- National Science Challenges
- Performance Based Research Fund
- Primary Growth Partnership
- Strategic Science Investment Fund - Programmes
- Support for Industry research

COVID-19 rapid research response

In April 2020, the Health Research Council of New Zealand and the Ministry of Health provided funding for research related to COVID-19. The aim was to support New Zealand's immediate readiness and response to the threat of an outbreak as well as long-term challenges to health and wellbeing.

Two funded projects related to the development of diagnostic tests for COVID-19. Additional COVID-19 funding was provided for research-based innovations. Further information is presented in Chapter 3.

See [Rapid diagnosis and genome sequencing to follow CoV-2019 outbreak](#)¹³ and [DNA Diagnostics & Research Distinguishing COVID-19 from influenza with rapid 15-minute diagnostic](#)¹⁴ or [read more about the investment](#)¹⁵.

10. www.education.govt.nz/further-education/policies-and-strategies/centres-of-research-excellence-cores/ 11. www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/strategic-science-investment-fund/ 12. www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/r-d-tax-incentive/

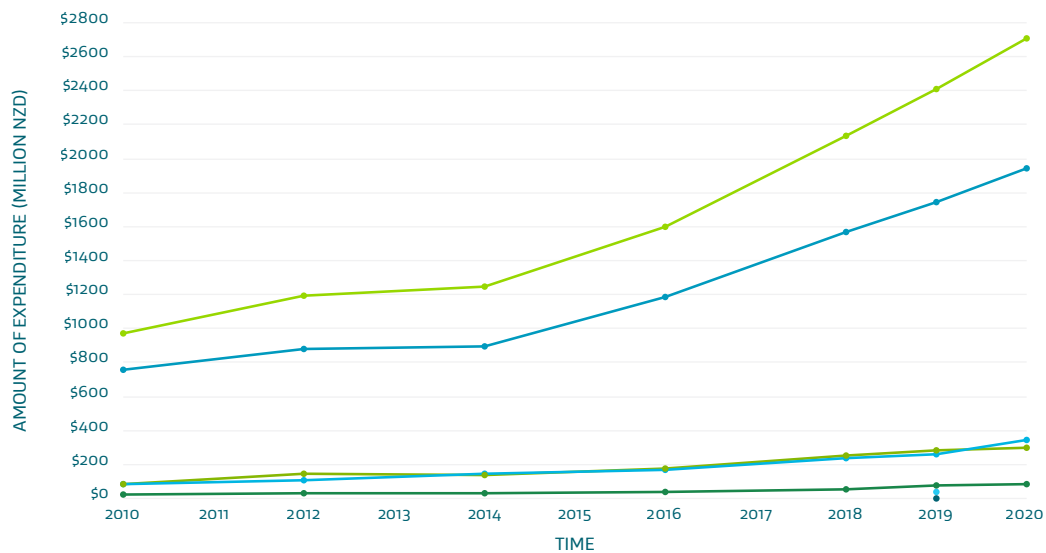
1.4 Ngā whakapaunga pakihi ki te R&D Business expenditure on R&D

FIGURE 8
Funding sources for business R&D expenditure

Businesses are likely to invest in their own R&D, but they also access other opportunities from public funding provided by government, tertiary institutions, overseas and other sources.

Total business expenditure on R&D (BERD) had a 2.8-fold increase over 2010–2020 (from \$971 to \$2,709 million). In 2020, 73 per cent of this increase amount (\$1,941 million) was contributed by businesses' own funds.

Funding for business R&D from other sources also increased. Government funding increased 3.6-fold from \$82 to \$295 million for 2010–2020. Funding from overseas sources grew 4.2-fold from \$81 to \$344 million for 2010–2020.



Data source:
Stats NZ research and development survey See page 101

Data for business expenditure comes from the [research and development survey](#)¹⁶. The figures include spending by businesses, universities, CRIs and government agencies. Dollar values are actual amounts.

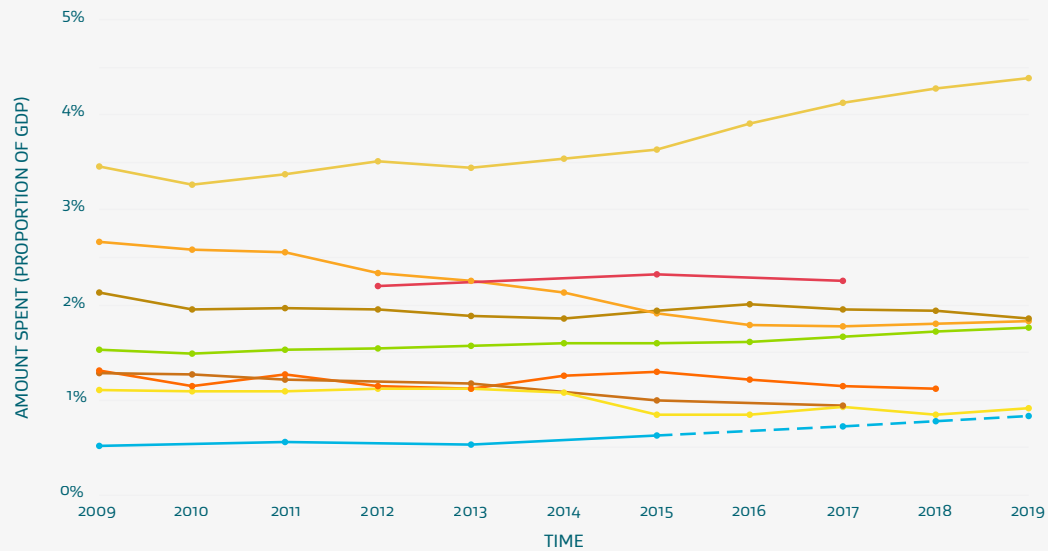
- Source of funding**
- Total
 - Own funds
 - Overseas
 - New Zealand government
 - New Zealand private sector
 - Other sources
 - Tertiary education

13. www.hrc.govt.nz/resources/research-repository/rapid-diagnosis-and-genome-sequencing-follow-cov-2019-outbreak
 14. www.hrc.govt.nz/resources/research-repository/distinguishing-covid-19-influenza-rapid-15-minute-diagnostics
 15. www.hrc.govt.nz/news-and-events/covid-19-research-funding-opportunities-available-now 16. www.stats.govt.nz/information-releases/research-and-development-survey-2019

FIGURE 9

Business expenditure on R&D as a percentage of GDP compared with other small advanced economies

Despite recent increases, business expenditure on R&D in New Zealand is relatively low compared with other small advanced economies. This is partly due to the large number of small businesses that are less likely to undertake R&D, as well as the predominance of businesses in industries with historically low levels of R&D.



Data source:

OECD main science and technology indicator. See page 101
Stats NZ research and development survey. See page 101

Data for business expenditure comes from the [research and development survey](#)¹⁷. The OECD offsets New Zealand R&D survey data by one year for comparative purposes (ie 2018 Stats NZ R&D data is shown as 2017 OECD data). The figures include spending by businesses, universities, CRIs and government agencies. New Zealand's R&D expenditure was weighted by GDP using OECD data to enable comparisons with other countries. National currency data was converted to USD using the [purchasing power parity](#)¹⁸ series from the OECD National Accounts Division. See [further information](#)¹⁹. Data for 2017 and 2018 was recalculated based on revised 2020 research and development survey data. Data for 2019 was approximated based on 2020 survey data. The dashed line leads through the approximated values.

Country/region

- Israel
- Switzerland
- Denmark
- Finland
- OECD - Total
- Singapore
- Australia
- Ireland
- New Zealand

Temporary R&D loan scheme

Supporting businesses to continue R&D in the COVID environment

Disruptions caused by the COVID-19 pandemic put business R&D programmes at risk of being cut or put on hold, with urgent and short term needs taking priority. This temporary government scheme provided loans of up to \$400,000 to eligible business to fund planned R&D programmes. It recognised that high-value R&D activity would contribute to a faster economic recovery by creating new export opportunities and increasing New Zealand's productivity.

[Read more](#)²⁰

1.5 Ngā whakapaunga kāwanatanga ki te R&D

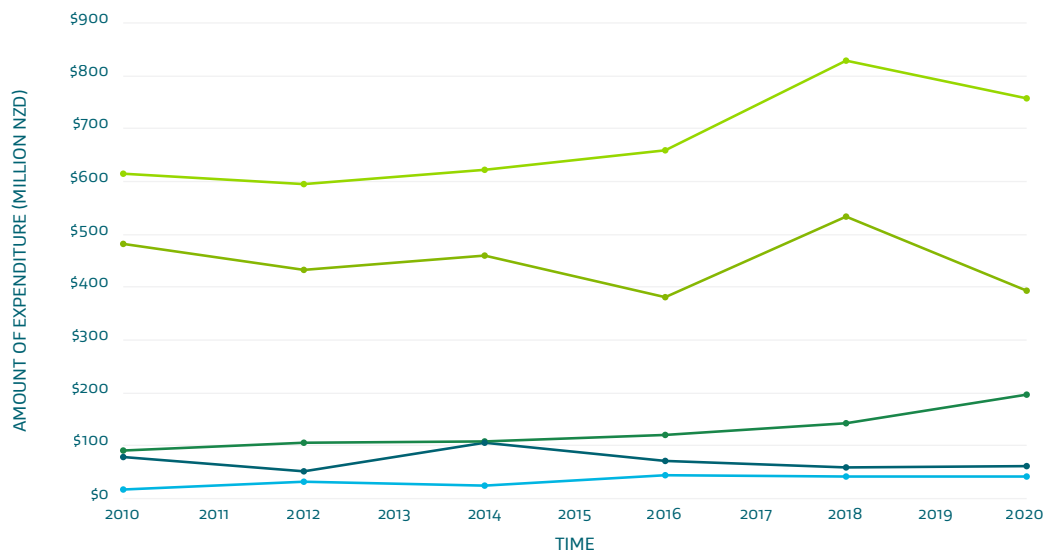
Government expenditure on R&D

FIGURE 10
Funding sources for government R&D expenditure

Total government expenditure on R&D (GovERD) increased by 23.3 per cent between 2010 and 2020, primarily through greater public funding. Funding from business increased by 1.2-fold during this time.

Most government R&D is carried out by Crown research institutes, which also receive contracts or grants from private and overseas funders.

In 2020, R&D funding from government was more than half (52%) of the total amount of government expenditure on R&D. This was followed by private sector funding and overseas funders, which contributed 32 per cent towards government expenditure on R&D.



Data source:
Stats NZ research and development survey See page 101

Data for government expenditure comes from the [research and development survey](#)²¹. The figures include spending by businesses, universities, CRIs and government agencies. The source titled 'own funds' is included in the New Zealand government source of funding category. Dollar values are actual amounts.

Source of funding

- Total
- New Zealand government
- New Zealand private sector
- Own funds
- Overseas

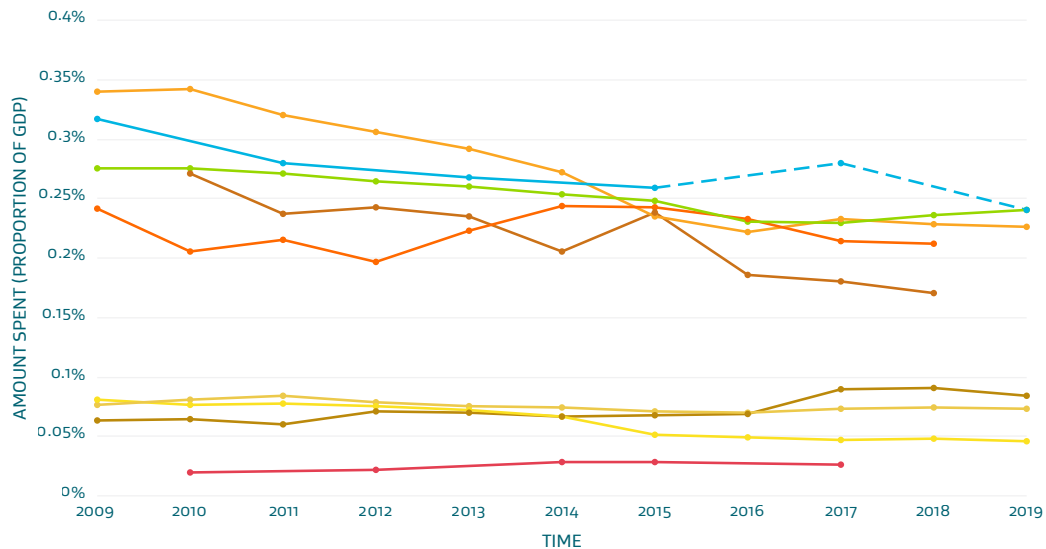
21. www.stats.govt.nz/information-releases/research-and-development-survey-2020

FIGURE 11

Government expenditure on R&D as a percentage of GDP compared with other small advanced economies

Government R&D expenditure as a percentage of GDP in New Zealand was relatively high compared with other small advanced economies. However, from 2009 to 2019 this expenditure decreased from 0.32 to 0.24 per cent of GDP.

Funding for CRIs makes up a large part of government expenditure on R&D. These organisations have a unique and important role to support innovation and growth in relevant sectors. They are also tasked with addressing New Zealand's most pressing issues and achieving economic growth by improving productivity and the sustainable use of natural resources.



Data source:

OECD main science and technology indicators See page 101
Stats NZ research and development survey See page 101

Data for Government expenditure comes from the [research and development survey](#)²². The OECD offsets New Zealand R&D survey data by 1 year for comparative purposes (ie 2018 Stats NZ R&D data is shown as 2017 OECD data). The figures include spending by businesses and institutions including universities, CRIs and Government agencies. New Zealand's R&D expenditure was weighted by GDP using OECD data to enable comparisons with other countries. National currency data was converted to USD using the [purchasing power parity](#)²³ series from the OECD National Accounts Division. See [further information](#)²⁴. Data for 2017 is recalculated based on revised 2020 Stats NZ R&D survey data and data for 2019 is approximated based on 2020 Stats NZ R&D survey data. The dashed line leads through the approximated values.

Country/region

- New Zealand
- OECD - Total
- Finland
- Singapore
- Australia
- Denmark
- Israel
- Ireland
- Switzerland



Red kiwifruit. Credit: Zespri™

CASE STUDY

LONG-TERM RESEARCH PARTNERSHIP RELEASES NEW RED KIWIFRUIT

Dr Zac Hanley, New Cultivar Innovation, Plant & Food Research

First there was green, then came gold, and now a brand new red kiwifruit is heading for supermarket shelves around the world. It's the latest variety to come from the Plant & Food Research–Zespri partnership and the culmination of two decades of intensive plant breeding, market research and horticultural trials.

"It didn't happen because one day we did a magic cross and produced a perfect fruit. It has to build over a series of steps, so our plant breeders need large reservoirs of patience and persistence. But the prize of several billion dollars of export income for New Zealand is a large one."

Zespri aspires to offer consumers their branded kiwifruit for 12 months of the year. The new red ripens earlier and will extend the season, as well as being quite different to current varieties. This colour was also identified as appealing to an Asian market.

In their native China, red is one of the colours produced by wild vines, but the genes for red also come mingled with those for small, soft, untransportable or tasteless fruit.

"None of them are nice. They need generations of breeding to improve them. Each plant takes 2–3 years to fruit but we follow them for up to 6, in case they're slow starters but turn out to be amazing. When you add that up, you're looking at 10–14 years from identifying an idea to a product."

More than half of the red prospects were destroyed by the kiwifruit vine disease PSA in 2010. "That put us behind by several years, so we had to devote more effort to catch up. Breeding for the climate of the future is becoming a matter of urgency, because fruit size and disease response is affected by night-time temperatures in winter and spring."

Zac says Zespri and Plant & Food Research have a close-knit partnership. Individual relationships at every level make a difference, right from the CEO and board level to business managers and scientists.

"We agree what the targets are for the next 15 years, so we require as much free information exchange as possible. That level of openness highlights the trust shared between us."

The funding model also enables Plant & Food Research to reinvest in the programme. "Zespri provide us with a share of the royalties, which gets fed back into supporting more kiwifruit research. This benefits the wider kiwifruit industry and New Zealand's economy. Ultimately we're trying to create a virtuous circle that loops back and allows us to provide even more benefit."

The kiwifruit breeding programme has more than 150 staff. It is supported by the Strategic Science Investment Fund, the Endeavour Fund, industry partnerships and reinvested royalty returns. In 2020 Zespri licensed 150 hectares to growers for commercial production of red kiwifruit with plans for this to build to 1500 hectares by 2023 if market feedback remains positive. At full production, that area could produce 15 million trays of Zespri Red Kiwifruit and return more than \$250 million per year in export earnings.

1.6 Ngā whakapaunga mātauranga matua ki te R&D Higher education expenditure on R&D

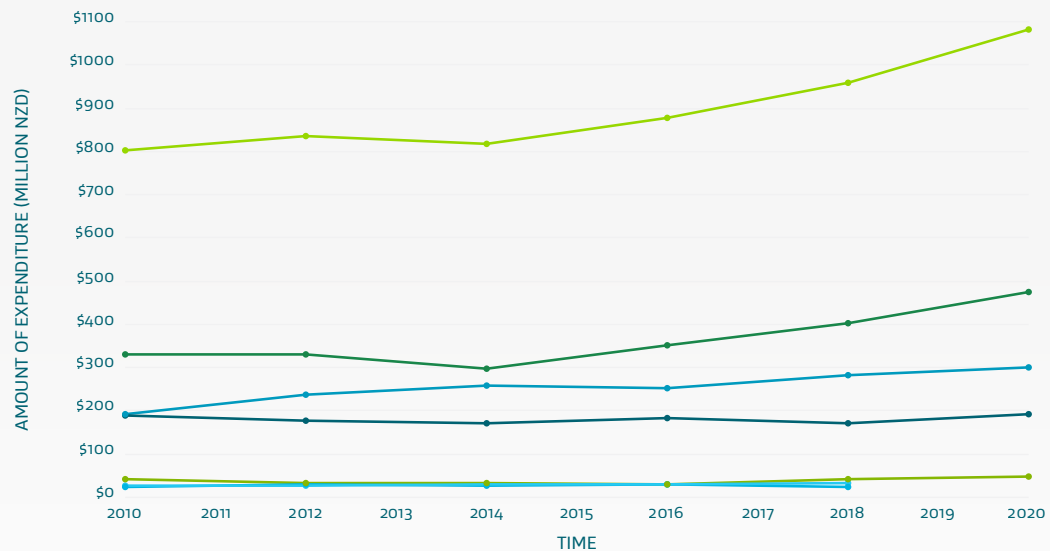
22

FIGURE 12

Funding sources for higher education R&D expenditure

Total expenditure for higher education on R&D (HERD) rose by about 35 per cent for 2010–2020 from \$802 to \$1082 million. Approximately 44 per cent of funding over this period came from government, with a small amount from business and overseas sources (between 4.5 and 8.1%).

Since 2010, almost half of the total R&D funding for higher education came from universities and other tertiary institutions. These institutions have a special role as research enables teaching staff to stay at the forefront of their field. These institutions also develop the next generation of scientists and innovators through doctoral and other postgraduate degrees.



Data source:

Stats NZ research and development survey See page 101

Data for higher education expenditure comes from the [research and development survey](#)²⁴. The figures include spending by businesses, universities, CRIs and government agencies. Dollar values are actual amounts.

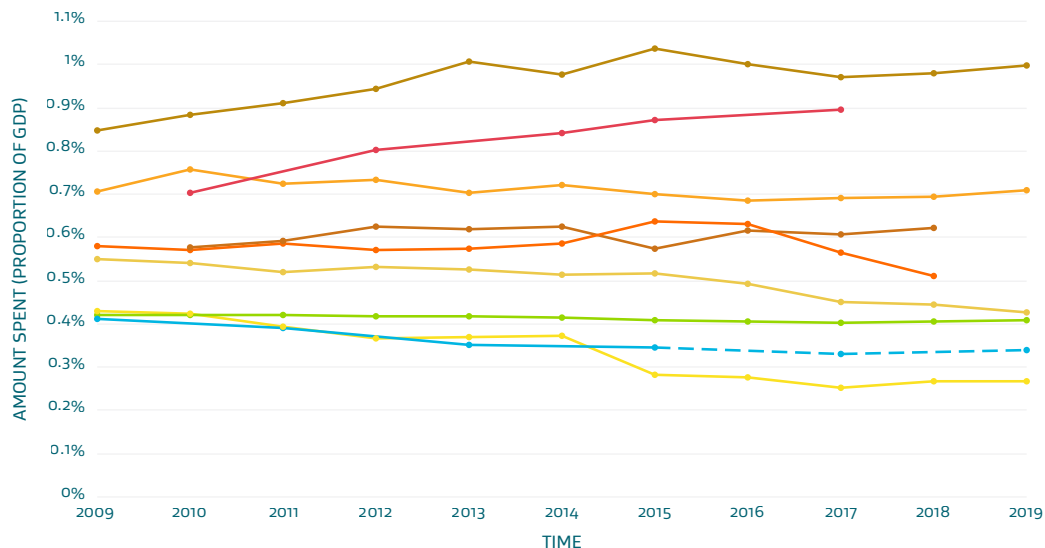
Source of funding

- Total
- New Zealand research contracts (government)
- Own funds
- Tertiary Education Commission
- New Zealand private sector
- Other
- Overseas

FIGURE 13

Higher education expenditure on R&D as a percentage of GDP

New Zealand’s higher education expenditure on R&D fell from 0.41 per cent of GDP in 2009 to 0.34 per cent in 2019. A similar decrease was observed in some other small advanced economies (Israel, Singapore and Ireland), while others (Denmark, Switzerland and Ireland) had increases during the same period.



Data source:

OECD main science and technology indicators See page 101
Stats NZ research and development survey See page 101

Country/region

- Denmark
- Switzerland
- Finland
- Australia
- Singapore
- Israel
- OECD - Total
- New Zealand
- Ireland

The OECD offsets New Zealand R&D survey data by 1 year for comparative purposes (ie 2018 Stats NZ R&D data is shown as 2017 OECD data). New Zealand’s R&D expenditure was weighted by GDP using OECD data to enable comparisons with other countries. National currency data was converted to USD using the [purchasing power parity](#)²⁶ series from the OECD National Accounts Division. See [further information](#)²⁷. Data for 2017 was recalculated based on revised 2020 Stats NZ R&D survey data and data for 2019 was approximated based on 2020 Stats NZ R&D survey data. The dashed line leads through the approximated values.

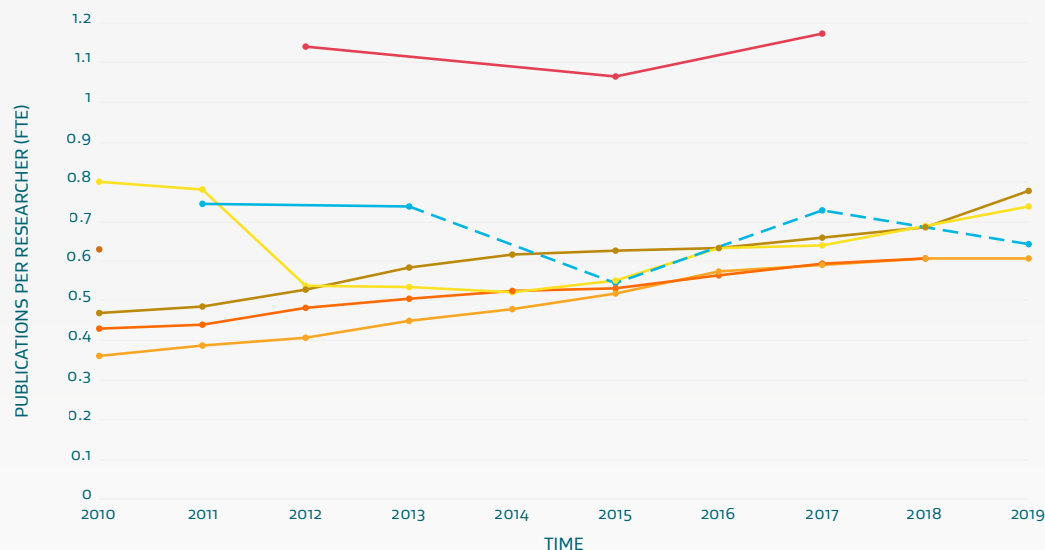
1.7 Ngā whakaputaranga rangahau Research productivity

24

FIGURE 14
Publications per researcher compared with other small advanced economies

The publications per researcher metric provides a partial view of research productivity. This is because research can take several years to publish and some fields produce more publications than others.

In 2015, there was a change in the way that researchers were counted, with Masters students being included in the researcher count from that year. This has resulted in a drop in the number of publications per researcher. Since 2015, the number of publications per New Zealand researcher has been between 0.54 and 0.73.



Data source:

[Dimensions bibliometrics data](#) See page 100

[OECD main science and technology indicators](#) See page 101

[Stats NZ research and development survey](#) See page 101

Publications per researcher are measured annually. The number of publications with authors affiliated to New Zealand research institutions is calculated with data from [Dimensions](#)²⁸. The OECD offsets NZ data on researcher workforce (as full time equivalents) by 1 year for comparative purposes (ie 2018 Stats NZ R&D data is shown as 2017 OECD data).

Note: Masters students have been included in the researcher count since 2015. Data for 2015 and 2017 was recalculated based on revised 2020 Stats NZ R&D survey data and data for 2019 was approximated using 2020 Stats NZ R&D survey data. The dashed line leads through the approximated values.

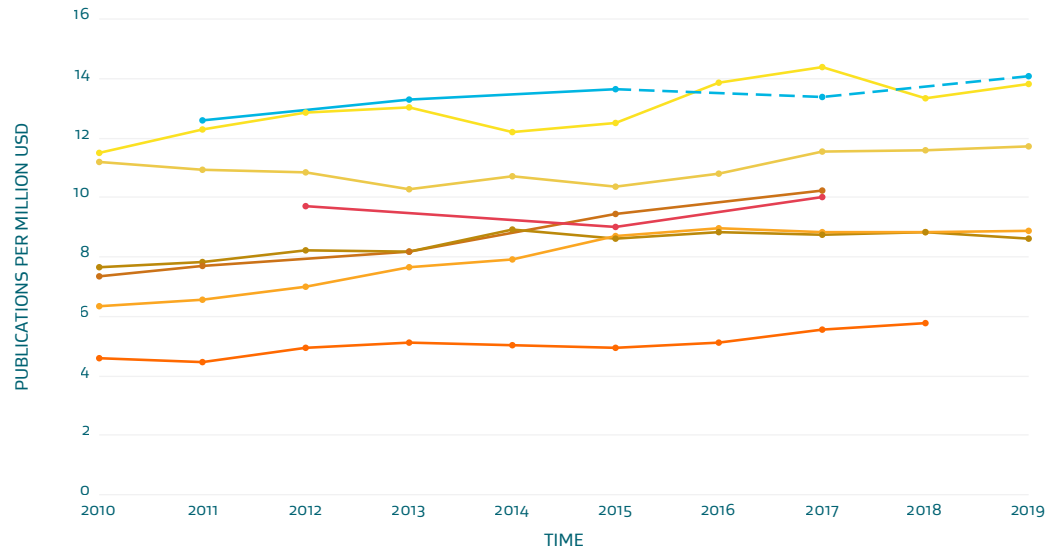
Country/region

- Switzerland
- Denmark
- Ireland
- New Zealand
- Australia
- Finland
- Singapore

FIGURE 15
Publications per million dollars spent compared with other small advanced economies

New Zealand researchers consistently produce a high number of publications per dollar spent when compared to Australia and most small advanced economies (except for Ireland).

The number of New Zealand publications per dollar spent increased by 13 per cent from 2011 to 2019.



Data source:

[Dimensions bibliometrics data](#) See page 100

[OECD main science and technology indicators](#) See page 101

[Stats NZ research and development survey](#) See page 101

Publications per dollar spent are measured annually. The number of publications with authors affiliated to New Zealand research institutions is calculated with data from [Dimensions](#)²⁸. The OECD offsets New Zealand data by 1 year for comparative purposes (ie 2018 Stats NZ R&D data is shown as 2017 OECD data). National currency data was converted to USD using the [purchasing power parity](#)²⁹ series from the OECD National Accounts Division. See [further information](#)³⁰. Expenditure on research by business is excluded. Data for 2017 was recalculated based on revised 2020 Stats NZ R&D survey data and data for 2019 was approximated using 2020 Stats NZ R&D survey data. The dashed line leads through the approximated values.

Country/region

- New Zealand
- Ireland
- Israel
- Australia
- Switzerland
- Finland
- Denmark
- Singapore

29. www.oecd.org/sdd/prices-ppp/ 30. www.oecd.org/sti/inno/MSTI_documentation_e.pdf

CHAPTER 2

Ngā papa me ngā momo rangahau

Fields and types of research

Kei roto i tēnei wāhanga

In this chapter

- | | |
|---|----|
| 2.1 Ngā ia kei ngā papa rangahau
Trends in research fields | 28 |
| 2.2 Ngā ia kei ngā momo rangahau
Trends in types of research | 31 |



Kupu whakataki Introduction

New Zealand researchers continue to be active in a wide range of existing and emerging research fields. This research activity is supported by the research, science and innovation system, which funds a balance of research across the research spectrum (basic research, applied research, experimental development).

Outputs, such as research publications, record and communicate the new knowledge generated through research. By tracking these outputs, the quality and efficiency of New Zealand's research system and its specialities can be identified.

The government provides funding, leadership and structures to encourage and support actions that are likely to have the most social value. This includes directing research and development (R&D) to societal and environmental challenges through:

- basic research – experimental or theoretical work that aims to acquire new knowledge without any particular application or use in view
- applied research – original investigations to acquire new knowledge with specific, practical aims or objectives
- experimental development – systematic work to produce new products or processes or improve existing products or processes.

This chapter explores changes and trends in research fields, and types of research and development activity.

Ngā miramira wāhanga Chapter highlights

Expenditure in basic research, applied research and experimental development increased between 2010 and 2020.

The largest increases were in experimental development and applied research – increases in business R&D expenditure are likely to have contributed to this finding.

New Zealand produces publications in all research fields.

More than a quarter (ie 30%) of publications in 2020 were from the medical and health sciences field.

Data indicates that New Zealand research is more specialised in Earth sciences and environmental sciences than the rest of the world. Specialisation in fields such as economics and mathematics, has reduced.

2.1 Ngā ia kei ngā papa rangahau Trends in research fields

FIGURE 16

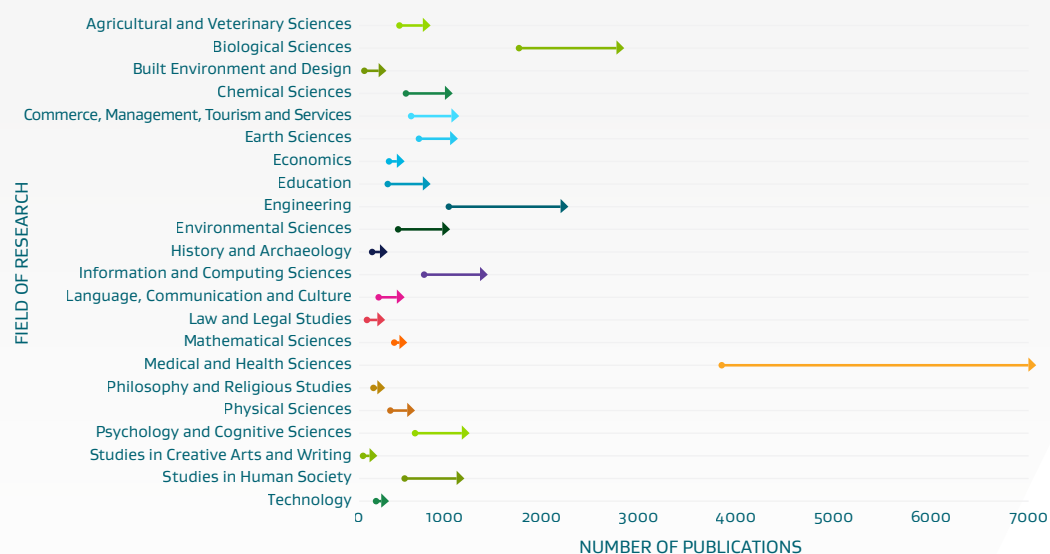
Change in number of publications by research field in 2010 and 2020

A change in the number of publications is used to indicate increases or decreases in research activity in a particular field. New Zealand produced more publications across all research fields in 2020 when compared to 2010. Research fields with the greatest proportional increases in the number of publications from 2010 to 2020 were:

- built environment and design (3.4-fold)
- studies in creative arts and writing (2.6-fold)
- law and legal studies (2.4-fold)
- education (2.3-fold)
- engineering (2.3-fold).

In 2020, three fields accounted for approximately half (51%) of all publications:

- medical and health sciences (30%, 6804 publications)
- biological sciences (12%, 2621 publications)
- engineering (9%, 2053 publications).



Data source:

Dimensions bibliometrics data See page 100

A field of research is assigned to every publication (with New Zealand affiliated authors) using the *Australian and New Zealand Standard Research Classification*¹. The data in the figure is for publications in these research fields in 2010 and 2020. The head of each arrow indicates the number of publications in 2020.

1. www.arc.gov.au/grants/grant-application/classification-codes-rfcd-seo-and-anzsic-codes

FIGURE 17
Change in relative number of publications by research field in 2010 and 2020

The relative number of publications is calculated using the revealed comparative advantage (RCA), which is the proportion of New Zealand publications in one field divided by the proportion of publications in the same field globally.

In 2020, New Zealand had a higher proportion of publications in some research fields relative to the rest of the world, as shown by RCA values that were greater than 1.0. New Zealand specialises in:

- Earth sciences (3.1)
- environmental sciences (3.0)
- commerce, management, tourism services (2.8)
- agricultural and veterinary sciences (2.6)
- biological sciences (2.1)
- studies in creative arts and writing (1.9)
- education (1.9).

In 2020, fields with RCA values less than 1.0 (ie fewer publications with New Zealand-affiliated authors than the rest of the world) were:

- mathematical sciences (0.6)
- physical sciences (0.6)
- technology (0.6)
- history and archaeology (0.8)
- chemical sciences (0.8).

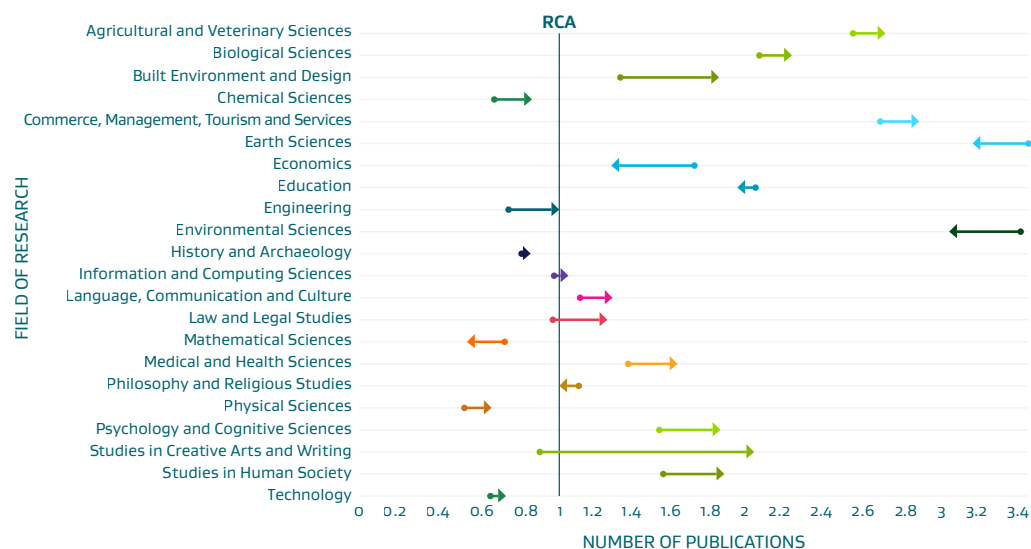
Research fields with the greatest increases in RCA values in 2010 and 2020 were:

- studies in creative arts and writing (from 0.9 to 1.9),
- built environment and design (from 1.3 to 1.8)
- studies in human society (from 1.5 to 1.8)
- psychology and cognitive sciences (from 1.5 to 1.8).

Research fields with the greatest decreases in RCA values in 2010 and 2020 were:

- economics (from 1.7 to 1.3)
- environmental sciences (from 3.3 to 3.0)
- Earth sciences (from 3.4 to 3.1).

Decreases in RCA values may indicate that the amount of research in these fields in New Zealand is not keeping pace with the world as a whole. This is despite the increases observed in the number of publications in some fields such as information and computing sciences.



Data source:
Dimensions bibliometrics data See page 100

The revealed comparative advantage (RCA) is the proportion of New Zealand publications in one field divided by the proportion of publications in the same field globally. An RCA >1 shows that New Zealand is more active in a research field than the rest of the world. The head of each arrow indicates the RCA value in 2020.

Te Mana Raraunga

Māori Data Sovereignty Network

Te Mana Raraunga advocates for Māori rights and interests in data and for the development of Māori data infrastructure and capability. With more than 100 Māori researchers, practitioners and entrepreneurs, it is enabling a cohesive voice across the science system. There remains much to do to ensure Crown agencies deliver on their Treaty obligations to Māori, including in the RSI sector.

With Maiam Nayri Wingara, their Australian counterpart, Te Mana Raraunga successfully advocated for including indigenous studies in the Australia New Zealand Standard Research Classification.

Te Mana Raraunga also worked with other indigenous data sovereignty networks to found the Global Indigenous Data Alliance. The alliance has created [CARE principles for indigenous data governance](#)², which are part of a revised [AIATSIS Code of Ethics](#)³.

[Read more about Te Mana Raraunga](#)⁴

New Zealand Research Information System

A new hub for information about the research, science and innovation sector

The system, which is currently in development, will provide data about research as well as the funding and resources that support the RSI sector. It covers current research projects, who's involved in them, information about spending in a particular area and will highlight which areas need more resources and support.

Initially, data will come from organisations that fund research (eg Health Research Council, Ministry of Business, Innovation and Employment, Royal Society Te Apārangi) and those that carry out research (eg Crown research institutes, universities). Over time more organisations are expected to contribute.

[Read more](#)⁵

Review of research classification codes

The Australian New Zealand Standard Research Classifications (ANZSRC) provide standard definitions to classify, identify and count different types of research. In a joint project, the ANZSRC codes were reviewed in 2020 by the Australian Bureau of Statistics, Australian Research Council, the Ministry of Business, Innovation and Employment and Stats NZ. This was the first review since the classification was released in 2008.

A key outcome was the inclusion of a new division for indigenous research. This will enable Māori and Pacific Peoples' research to be better identified, counted and recognised.

[Read more](#)⁶

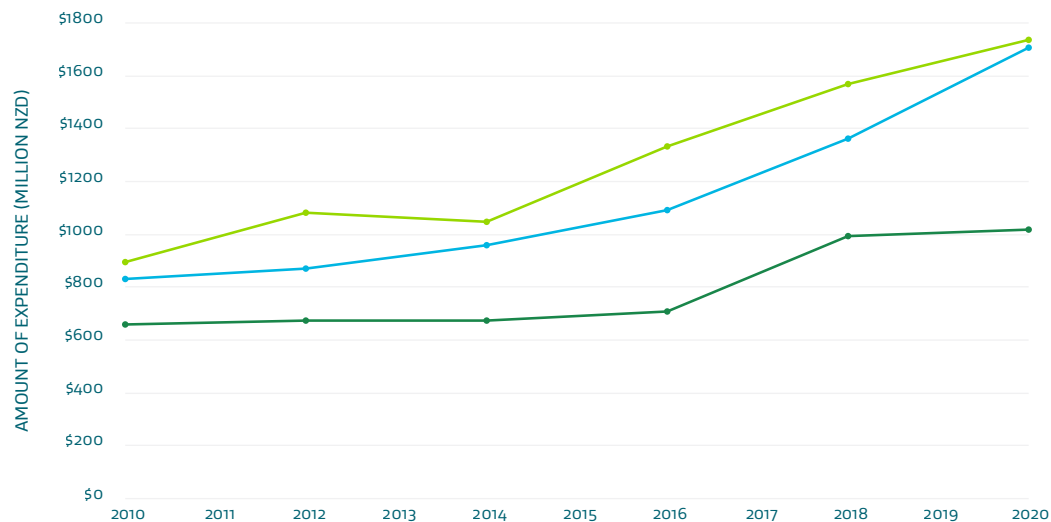
2.2 Ngā ia kei ngā momo rangahau Trends in types of research

FIGURE 18
R&D expenditure by type of research

R&D expenditure includes three types of research activity – basic research, applied research and experimental development. Expenditure on R&D increased for all three types between 2010 and 2020. The increase in experimental developmental (2.0-fold) was greater than the increases in basic research (1.5-fold) and applied research (1.9-fold).

In 2020, experimental developmental and applied research each comprised approximately 39 per cent of R&D expenditure, with the remaining 23 per cent being spent on basic research.

These changes may be largely explained by the increase in business R&D expenditure, which is much less likely to include basic research than R&D expenditure by government or higher education sectors.



Data source:
Stats NZ research and development survey See page 101

Data for R&D expenditure comes from the [research and development survey](#)⁷.

Type of research

- Applied research
- Experimental development
- Basic research

2. www.gida-global.org/care 3. aiatsis.gov.au/research/ethical-research/code-ethics 4. www.temanararaunga.maori.nz/ 5. www.mbie.govt.nz/science-and-technology/science-and-innovation/research-and-data/nzris/ 6. aria.stats.govt.nz/aria/?_ga=2.199036335.1464857491.1611621241-1927624054.1602460672#ClassificationView:uri=http://stats.govt.nz/cms/ClassificationVersion/d3TYSTsmz2uc8CY1 7. www.stats.govt.nz/information-releases/research-and-development-survey-2020

CHAPTER 3

Te whakatipu i te auahatanga pakihi

Growing business innovation

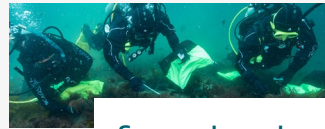
Kei roto i tēnei wāhanga

In this chapter

- 3.1 Ngā ia auahatanga Trends in innovation 34
- 3.2 Ngā ia kei te R&D pakihi Business R&D trends 40
- 3.3 Te whakapiki i te maha me te rahi o ngā pakihi hou Increasing the number and scale of start-ups 43

He mātai take

Case studies



Seaweed supplement enables low-methane agriculture → 38



Galvanising action to reduce waste, prevent pollution and save money → 46

Kupu whakataki Introduction

Innovation is the development or introduction of any new or significantly improved products, processes or methods. This includes products, processes and methods that a business was the first to develop and those that have been adopted from others. Innovation is essential for keeping pace with global technology, progress and productivity.

Innovation is critical for developing New Zealand industries and improving the productivity of our economy. Its benefits – including new businesses, industries and highly skilled jobs – spill over into society.

Rates of innovation in New Zealand businesses are low compared to the rest of the world. This has been attributed to a small proportion of businesses being in R&D-intensive industries, the cost of innovation, a small domestic market and little competition. There are also the challenges of our geographic isolation, a lack of connectivity across research and industry networks, and a lack of research capability to address business technology needs.

The Research and Development Tax Incentive has been available to eligible businesses since the 2019/20 tax year. It is expected to increase R&D activity in businesses, as well as R&D uptake across different industries. COVID-19 is expected to affect business R&D expenditure in the current year. The temporary R&D Loan Scheme was introduced to support affected businesses to continue their investment in R&D.

This chapter explores innovation trends, including industry type and size, as well as capital investment into early-stage businesses.

Ngā miramira wāhanga Chapter highlights

R&D expenditure has increased in most industry groups since 2012. There has been significant growth in R&D expenditure in the computer services industry, which increased 4.2-fold between 2012 and 2020.

The highest R&D expenditure by industry group in 2020 was computer services (\$924 million) and manufacturing (\$825 million).

Compared to other types of innovation, **New Zealand businesses spend most on product development**, with a focus on introducing new goods and services to the market.

Larger businesses (with 500+ employees) account for most of New Zealand's total business expenditure on R&D and undertake the most product innovation.

The proportion of businesses that innovate in New Zealand is low compared with other small advanced economies, and is declining. However, **business expenditure on innovation is increasing.**

Investment in start-ups in New Zealand has been generally increasing over time, driven almost entirely by the software and services sector, which saw a 6.6-fold increase in investment between 2010 and 2020.

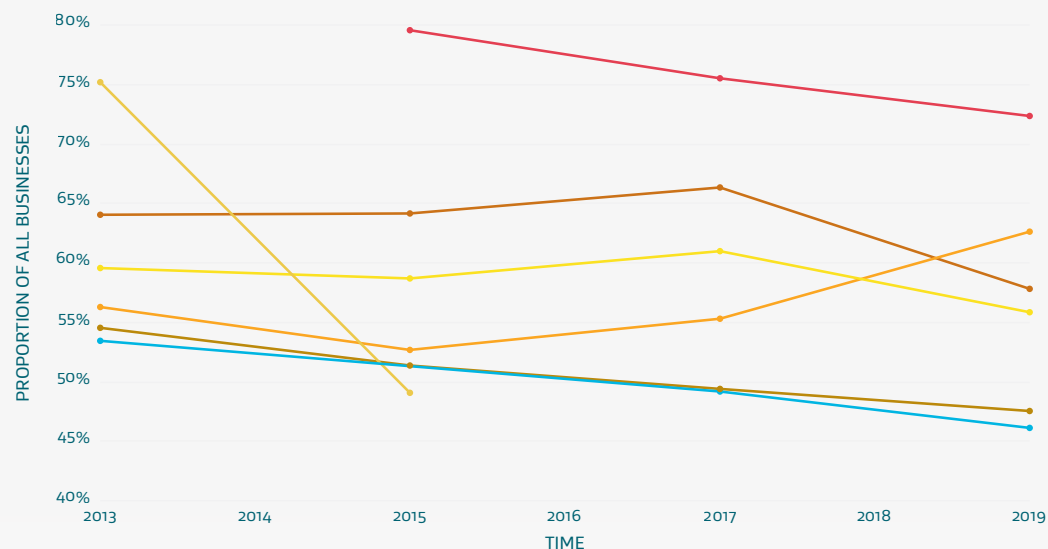
3.1 Ngā ia auahatanga Trends in innovation

FIGURE 19

Proportion of businesses that innovate compared with other small advanced economies and Australia

Innovative activity in New Zealand is lower than in other small advanced economies and Australia.

The proportion of businesses that innovate decreased from 53 to 46 per cent between 2013 and 2019. This trend was observed in most small advanced economies and in Australia.



Data source:

OECD business innovation statistics and indicators See page 100

Innovative activity in business is measured using the Stats NZ business operations survey¹. The survey identifies four types of innovation: product innovation, process innovation, marketing innovation and organisational innovation. Innovative businesses do one or more type. The survey is carried out in businesses with six or more employees only.

Country/region

- Switzerland
- Finland
- Australia
- Ireland
- Israel
- Denmark
- New Zealand

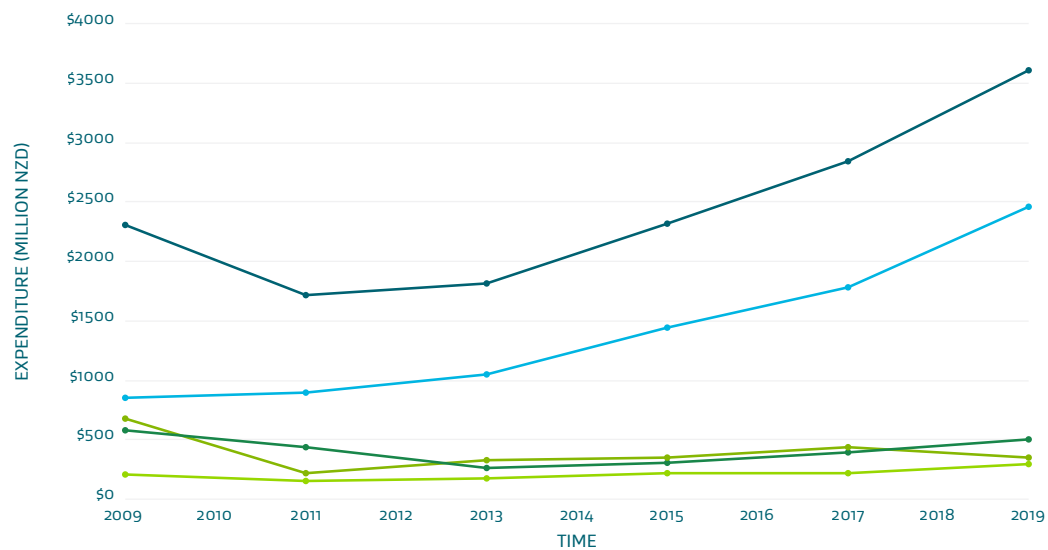
1. www.stats.govt.nz/information-releases/business-operations-survey-2019

FIGURE 20
Expenditure on innovation by type of innovation

Product innovation includes introducing new goods and services. Businesses that self-identify as carrying out product innovation are presented in figure 20. Expenditure on innovation increased by 56 per cent across all businesses that carry out product innovation between 2009 and 2019. The increased expenditure was primarily in R&D, which increased 2.9-fold during this decade.

Expenditure on design increased by 40 per cent, and expenditure on marketing and market research decreased by 48 per cent between 2009 and 2019.

The proportion of businesses undertaking innovation declined (figure 19) but the total expenditure on innovation has increased.



Data source:
Stats NZ business operations survey See page 101

Innovative activity in business is measured using the [Stats NZ business operations survey](#)¹. In the survey, innovation is defined as the development or introduction of any new or significantly improved activity for the business. This includes products, processes and methods that the business was the first to develop and those that have been adopted from other organisations. Dollar values are actual amounts.

Type of innovation

- Total product development and related activities expenditure
- Research and development
- Other expenditure related to product development
- Marketing and market research
- Design

R&D Tax Incentive

The incentive offers most New Zealand-based businesses a 15 per cent tax credit on money spent on R&D in New Zealand. Businesses that spend between \$50,000 and \$120 million a year on R&D may be eligible to make a claim. Other conditions may qualify those with a smaller spend.

Strong international evidence shows that tax incentives are the most effective way to lift R&D investment by businesses. This approach supports R&D throughout the economy without favouring particular industries or sectors.

The R&D Tax Incentive was introduced on 1 April 2019. Future RSI reports will provide information on its uptake.

[Read more](#)²

2. www.rdti.govt.nz/

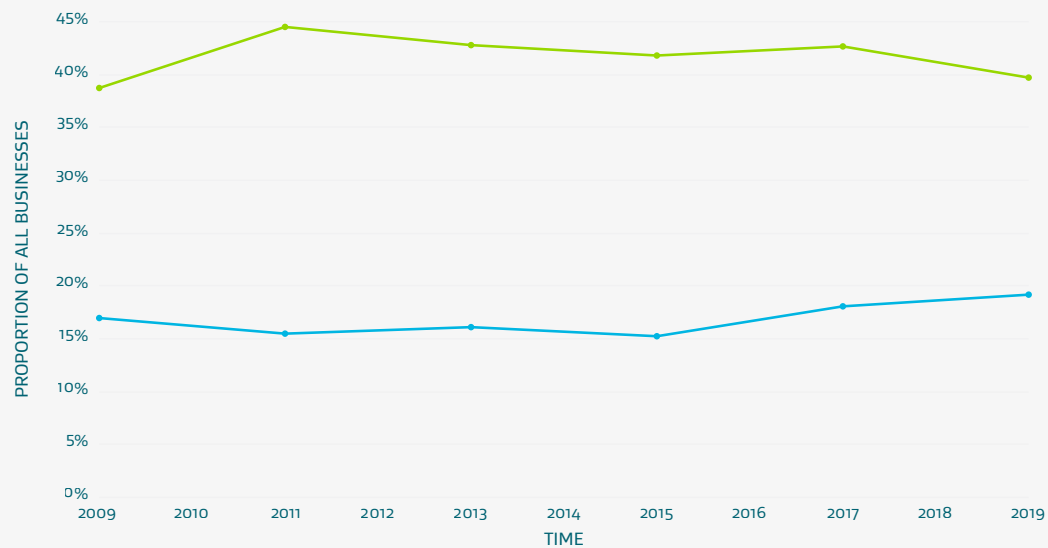
FIGURE 21

Innovation that is new to New Zealand or new to the world

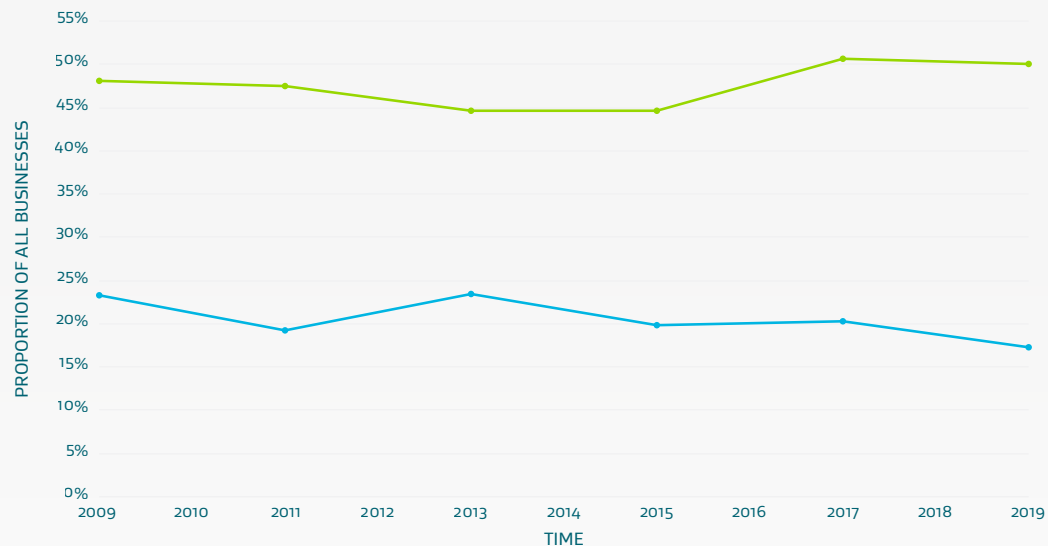
Innovation that is new to the world can give businesses an advantage over their competitors. Innovation that is new to New Zealand (adopting overseas innovations here) helps our businesses stay competitive internationally. While both types of innovation are important for productivity, distance from international markets may make it more challenging for local businesses to adopt international innovations.

Businesses carry out product innovation that is new to New Zealand at twice the rate of innovation than innovation that is new to the world. Larger businesses carry out more product innovation with new-to-New Zealand products. There is no clear difference in product innovation by business size for new-to-the-world innovation.

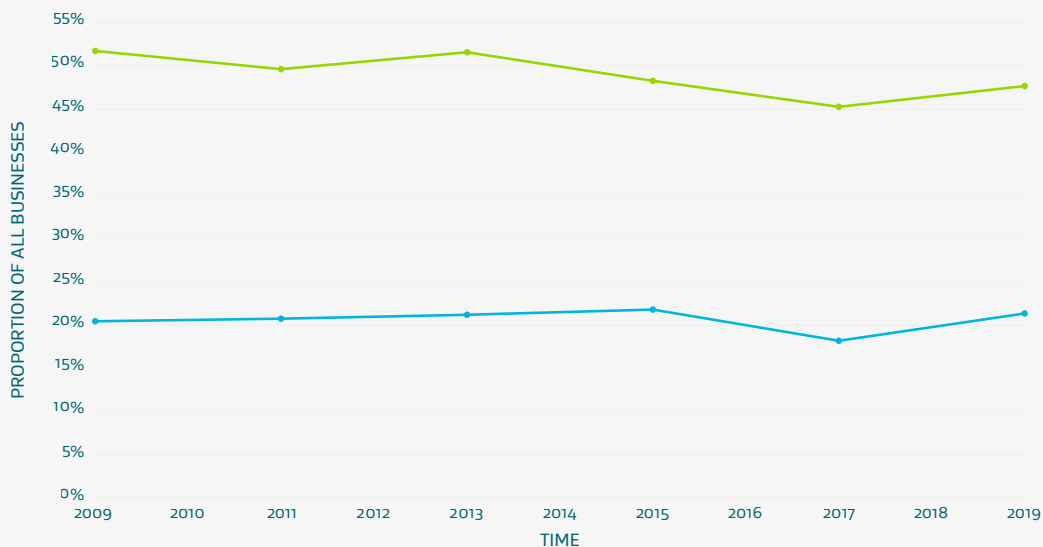
Company size 6-19 employees



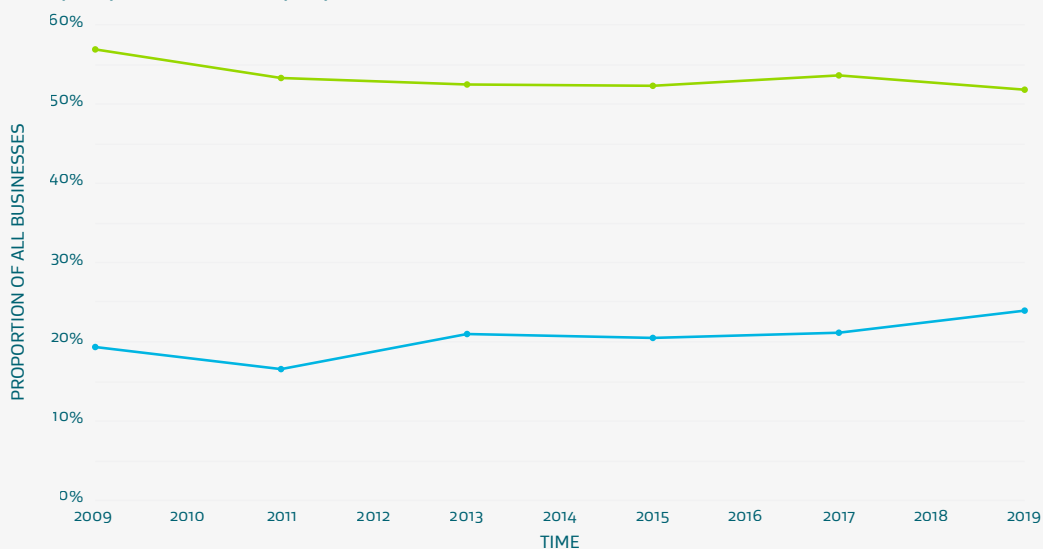
Company size 20-49 employees



Company size 50-99 employees



Company size 100+ employees



Data source:

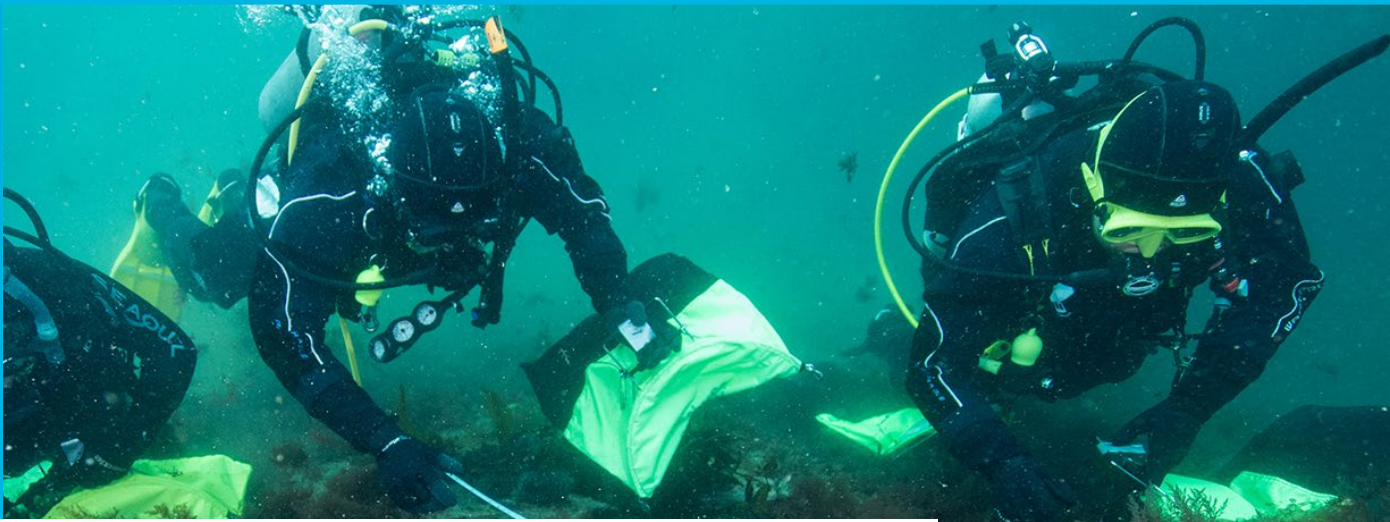
Stats NZ business operations survey See page 101

Innovative activity in business is measured using the [Stats NZ business operations survey](#)³. The survey reports the proportion of businesses that introduced new or significantly improved goods and services to the market in the last 2 financial years, and whether any of those were new to New Zealand or new to the world.

Sector totals

- New to New Zealand
- New to world

3. www.stats.govt.nz/information-releases/business-operations-survey-2019



CASE STUDY

SEAWEED SUPPLEMENT ENABLES LOW-METHANE AGRICULTURE

Divers harvesting Asparagopsis armata from the seabed

Alan Groves, Former Chief Operating Officer, CH₄ Global

A team of New Zealand entrepreneurs and scientists thought commercialising a natural methane-reducing supplement for cattle was too good an opportunity to miss. So they leapt right in.

“We have a pressing emissions problem to solve – and methane from agriculture is a problem worldwide, not just for New Zealand’s dairy and beef industries. This solution is proven to work, which is why we’re rushing to grow seaweed at scale.”

Asparagopsis armata is a red seaweed, native to New Zealand and southern Australia. It contains a simple chemical (bromoform) that is contained inside specialised cells in the plant. When released in a ruminant gut, bromoform inhibits the problematic methane-producing enzymes of digestive bacteria.

Until now, the only way to reduce methane emissions from burping cows has been to have fewer cows. “Nothing comes close to our supplement in terms of competition or for immediate impact. The beauty of

seaweed is that it’s been safely eaten by cows for hundreds of years so we can use it straight away.”

Trial results are consistent and impressive. The latest from June 2020 reported that steers fed dried seaweed daily at just 0.2 per cent showed a 98 per cent decrease in methane emissions and a 42 per cent increase in weight gain. No negative effects were found and no residues or changes were observed in organs or meat. Other studies have found the same applies to milk.

“Our first big challenge is processing. Once the seaweed is out of the water, bromoform starts to migrate out of the frond so we’re developing methodologies to minimise that loss across the entire value chain. We know that when it’s in a dried state it’s very stable.”

CH4 Global surveyed the extent of wild seaweed around Rakiura Stewart Island last winter and trialled harvesting, storage and processing techniques.

“I whakapapa to the island and have strong connections there. This has enabled us to forge good, respectful relationships with mana whenua and involve them in our plans. We’re always looking for opportunities to engage locals because it brings a better understanding of what we’re doing. We have also offered iwi, including Ngāi Tahu, the opportunity to be cornerstone investors in the business.”

The seaweed was freeze-dried by Back Country Cuisine in Invercargill, taking advantage of spare capacity. Growth, propagation and harvesting studies are underway to optimise the processing at each step. Aquaculture trials are being planned in New Zealand and Australia. One site is Big Glory Bay in Paterson Inlet/Whaka a Te Wera, Rakiura, making use of gear and knowledge repurposed from a now-closed oyster operation.

“*Asparagopsis* is native to that area, grows well and loves the excess nitrogen from the salmon farms. Seaweed aquaculture can improve water quality and provide habitat – it is such a low impact activity.”

“We want to set things up so people can grow *Asparagopsis* everywhere. The market is huge and this could be a whole new industry for our country – even as big as milk powder.”

Alan would like to acknowledge the University of Otago, NIWA and the South Australian Research and Development Institute as research providers, Ngāi Tahu, the Rakiura Stewart Island community and a \$500,000 grant from the Provincial Growth Fund. The use of dried and powdered *Asparagopsis* for methane reduction in ruminants was discovered and patented by CSIRO in Australia, which is licensing its use to CH4 Global⁴.

Alan Groves pointing out a Rakiura study site



3.2 Ngā ia kei te R&D pakihi

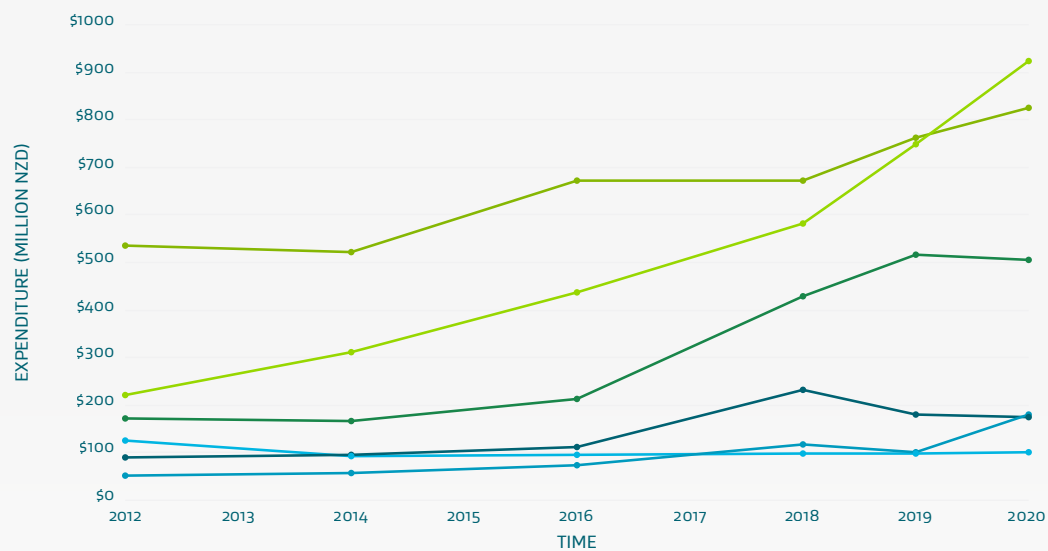
Business R&D trends

FIGURE 22

R&D expenditure by industry

R&D expenditure has increased in most industry groups since 2012, notably 4.2-fold in the computer services industry and 2.0-fold in the wholesale trade industry. Primary industry expenditure decreased by 19 per cent during this period.

In 2012, the largest expenditure on R&D was made by the manufacturing industry (45% of total business expenditure) and the computer services industry (19% of total business expenditure). These industries were also the largest contributors in 2020 at 30 and 34 per cent respectively. There have also been substantial increases in R&D expenditure by other service industries.



Data source:

Stats NZ research and development survey See page 101

Data for R&D expenditure comes from the [research and development survey](#)⁵. In 2019 the survey was conducted for the business sector only. The government and higher education sectors are surveyed every 2 years and are included in the 2020 survey. Many sub-industries make up other services, including software publishing, data processing, web hosting and electronic information storage services, market research, management and consulting, professional services and legal and accounting services. Dollar values are actual amounts.

Industry

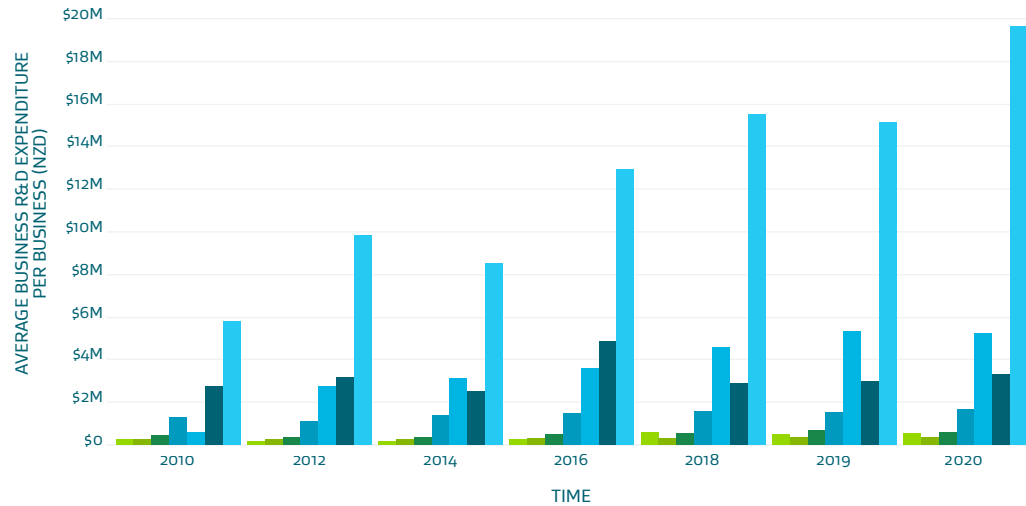
- Computer services
- Manufacturing total
- Other services
- Scientific research and technical services
- Wholesale trade
- Primary total

5. www.stats.govt.nz/information-releases/research-and-development-survey-2020

FIGURE 23
Average R&D expenditure by number of employees

In 2020, businesses with 500 or more employees accounted for 73 per cent of New Zealand’s total business expenditure on R&D.

Since 2010, the largest percentage growth in R&D expenditure has been by businesses with 1000+ employees and by businesses with 250–499 employees.



Data source:
Stats NZ business R&D data request See page 101

Business size is based on rolling mean employment. Average R&D expenditure data is based on the [2018 research and development survey](#)⁶. Dollar values are actual amounts.

Business size by number of employee

- 0
- 1-9
- 10-49
- 50-249
- 250-499
- 500-999
- 1000+

Data science for aquaculture builds the blue economy

The data science for aquaculture programme will contribute to a blue economy in New Zealand and a transition to a zero-carbon society.

It aims to develop innovative data science techniques to enable the aquaculture industry to produce high quality, low carbon protein efficiently and at scale.

New Zealand oversees the world’s 5th largest ocean estate. Also, the fishing industry is 50 per cent Māori-owned, with significant Māori ownership in aquaculture. Māori are, however, under-represented in data science courses at university. Bringing together marine scientists and specialists in machine learning, modelling and data visualisation will develop new science to support decision-making. This will equip farm managers to respond to climate challenges, manage disease, improve production yields and farm sustainably at scale.

[Read more](#)⁷

6. www.stats.govt.nz/information-releases/research-and-development-survey-2020 7. www.wgtn.ac.nz/news/2019/10/data-science-aquaculture-zero-carbon

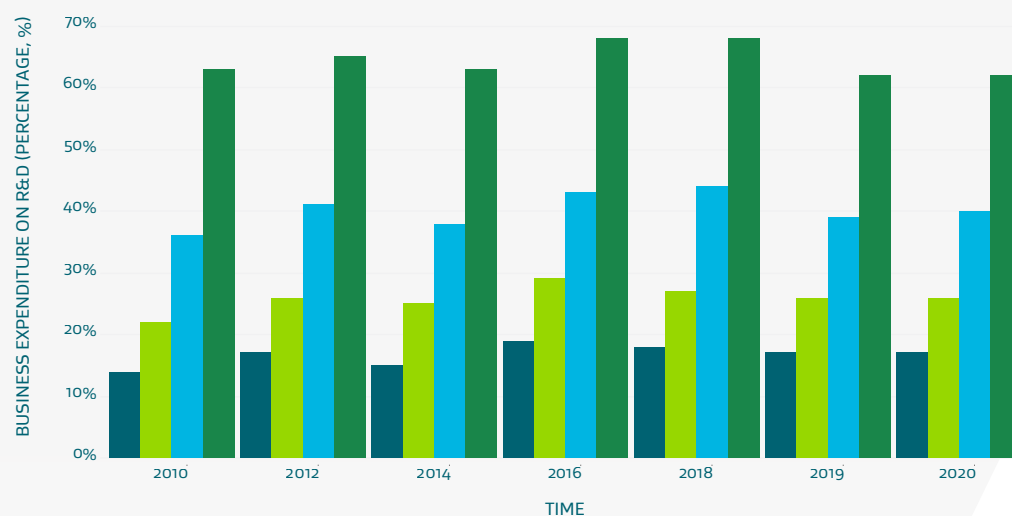
FIGURE 24 Concentration of R&D in top spending companies

New Zealand's expenditure on R&D is more concentrated than most other OECD countries (within the top 100 ranking businesses, see [OECD microBeRD project](#)⁸).

The concentration of R&D expenditure measures the proportion of total R&D expenditure by the top 5, 10, 25 and 100 spending companies. This metric has implications for the allocation and potential targeting of public support for business R&D.

The proportion of total innovative activity has become more concentrated in the top 5, 10 and 25 R&D performing businesses since 2010. In 2020, 62 per cent of R&D expenditure was made by the top 100 businesses and 40 per cent was made by the top 25 businesses.

The R&D Tax Incentive was designed to support a wider range of businesses to carry out R&D. It has been available to eligible businesses from the 2019/20 tax year.



Data source:

[Stats NZ business R&D data request](#) See page 101

R&D expenditure data is based on the [research and development survey](#)⁹. Dollar values are actual amounts.

Number of top ranking businesses

- Top 5
- Top 10
- Top 25
- Top 100

COVID-19 Innovation Acceleration Fund

This fund was open from April to June 2020 for research-based innovations to support New Zealand's COVID-19 response. It provided rapid, short-term support to develop and deploy new products, processes or services. These ranged from mass-production of diagnostics, ventilators and masks to marine tracking, modelling and pandemic preparedness. Fifty-six initiatives were supported by \$32.5 million in funding.

[Read more](#)¹⁰

⁸ www.oecd.org/sti/microberd.htm ⁹ www.stats.govt.nz/information-releases/research-and-development-survey-2020

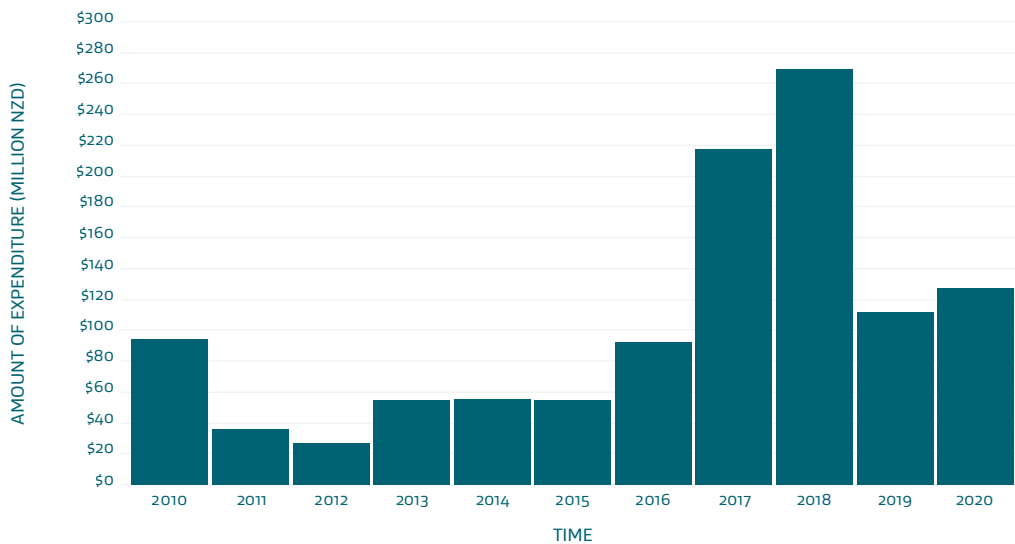
¹⁰ www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/covid-19-innovation-acceleration-fund/

3.3 Te whakapiki i te maha me te rahi o ngā pakihī hou

Increasing the number and scale of start-ups

FIGURE 25
Venture and early stage investment

Private investment can help companies grow by providing expert advice and support in addition to funding. Capital investment can be sourced from angel investors, venture capital and crowd-funding. Venture capital funds are the main source of private investments. Venture and early stage investment has generally increased over time in New Zealand, with large individual deals resulting in significant variations from year to year.



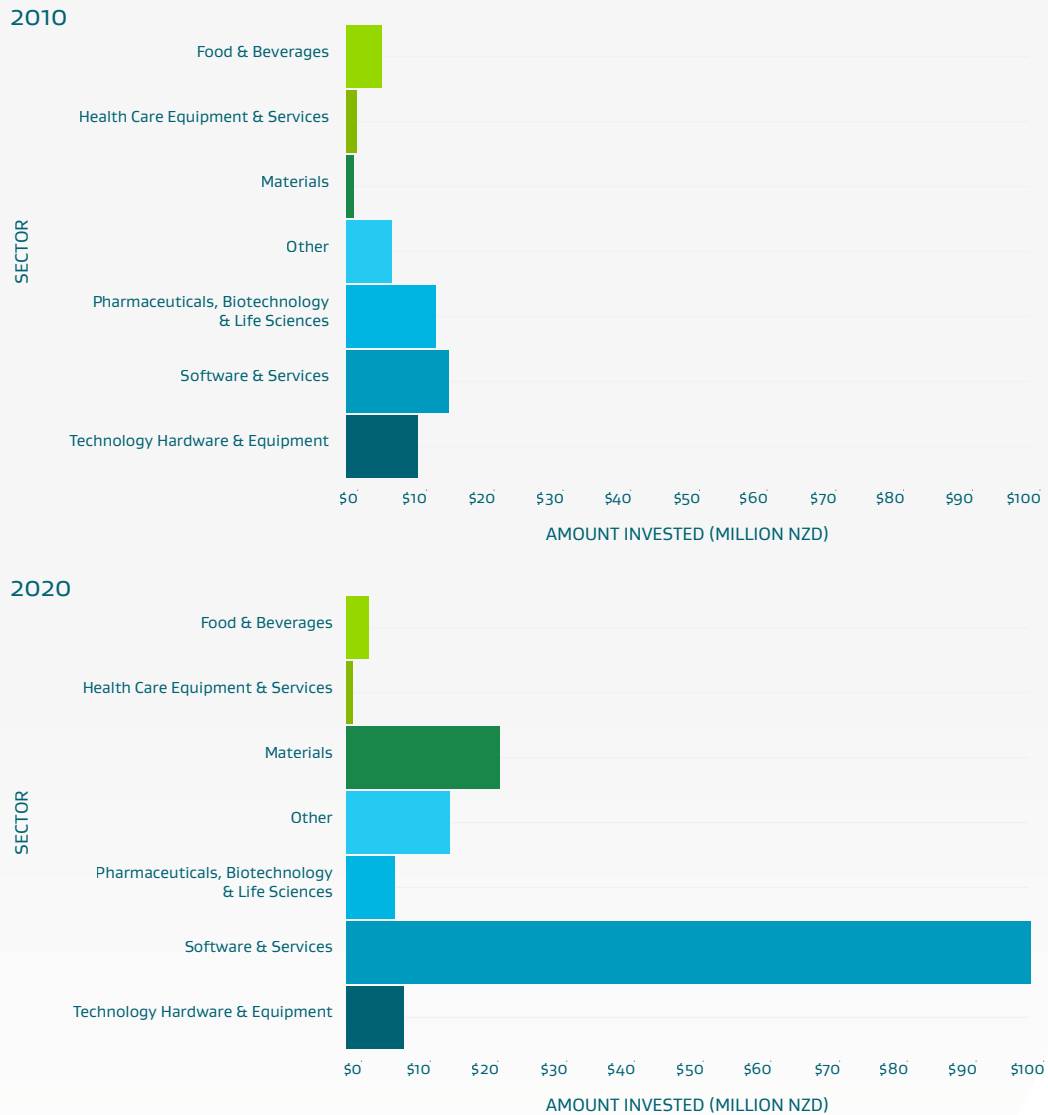
Data source:
[New Zealand Private Capital Monitor](#) See page 100

This data is from the New Zealand Private Capital Association and their New Zealand Private Capital Monitor, based on responses received from venture capital and private equity participants in the New Zealand market. The New Zealand Private Capital Association data also includes any publicly announced information as well as venture capital activity as reported in Startup Investment magazine and data collected by New Zealand Growth Capital Partners. Data presented is the total investment value of disclosed venture capital activity in New Zealand. This data is not comprehensive and should be viewed as indicative only. Dollar values are actual amounts.

FIGURE 26

Start-up investment by sector

Investment in start-ups in New Zealand has been generally increasing over time, driven almost entirely by the software and services sector that had a 6.6-fold increase in investment between 2010 and 2020. Start-ups in other sectors continued to attract venture capital but did not have the same growth in investment.

**Data source:**

New Zealand Growth Capital Partners See page 100

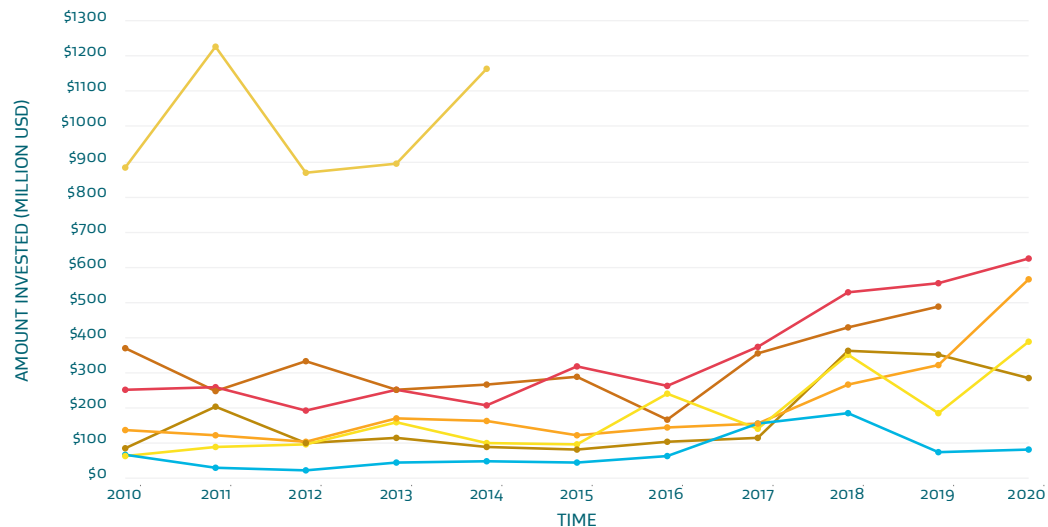
Data is from New Zealand Growth Capital Partners and based on self-reported start-up investment values from formal networks. The data differs from the New Zealand Venture Capital Association data in figure 25 due to differences in data classification and collection. This data is not comprehensive and should be viewed as indicative only. Dollar values are actual amounts. The category 'Other' includes private equity and venture capital investment in categories such as aerospace and defense, capital goods, consumer goods and apparel, transportation and unknown investments.

FIGURE 27

Venture capital investment compared with other small advanced economies

Venture capital investments in New Zealand increased by \$14.47 million between 2010 and 2020. Despite these increases, this type of investment is low in dollar terms compared with other small advanced economies.

Venture capital investment is likely to provide funding later than angel investors. The government-owned Elevate Venture Investment Fund has \$300 million to co-invest with the private sector into new venture capital funds.



Data source:
OECD enterprise statistics See page 101

Data for New Zealand is from New Zealand Venture Capital Association and their New Zealand Private Capital Monitor, which is based on responses received from venture capital and private equity participants in the New Zealand market. The New Zealand Venture Capital Association data includes any publicly announced information, as well as venture capital activity as reported in Startup Investment magazine and data collected by New Zealand Growth Capital Partners. Data presented is the total investment value of disclosed venture capital activity in New Zealand from the New Zealand Venture Investment Fund, which includes new businesses that are raising capital to scale up their activities. This data is not comprehensive and should be viewed as indicative only. Values are expressed in current USD prices. See [definition of venture capital as used in the OECD data](#)¹¹ and the [published metadata used by the OECD](#)¹². Further information on venture capital can be found in the OECD's [Entrepreneurship at a Glance report](#)¹³, page 126 and annex C.

Country/region

- Israel
- Switzerland
- Finland
- Australia
- Ireland
- Denmark
- New Zealand

11. www.oecd.org/sti/inno/2102064.pdf 12. stats.oecd.org/OECDStat_Metadata/ShowMetadata.ashx?DataSet=VC_INVEST
13. www.oecd-ilibrary.org/employment/entrepreneurship-at-a-glance-2017_entrepreneur_aag-2017-en



CASE STUDY

GALVANISING ACTION TO REDUCE WASTE, PREVENT POLLUTION AND SAVE MONEY

Jonathan (left) with Aaron Marshall

Jonathan Ring, CEO, Zincovery

A thin coating of zinc protects steel from corrosion and transforms it into a cheap and useful material. Galvanising makes sense from an environmental perspective but the need to clean the steel beforehand creates large quantities of concentrated acid waste, laced with iron and zinc.

The waste is currently treated by neutralising the acid, which causes most of the metals to drop out in a sludge. The sludge goes to landfill and the liquid is diluted before being released as wastewater. Zinc, however, accumulates in the environment and is extremely toxic to aquatic life, so even a small amount entering waterways is problematic.

“The whole treatment process is a massive waste of resources. It’s so much better to reuse the zinc than pollute the environment with it. Disposal is also expensive. It costs industry 3–4 times as much to dispose of the acid than to purchase it.”

Galvanising waste is not a new problem, but it is a difficult one because of the mix of metals and acid. The existing technologies are either very expensive or fail to recover the zinc. Jonathan became aware of the problem at the end of his bachelor’s degree in chemical and process engineering, and decided to take it on as a master’s research project.

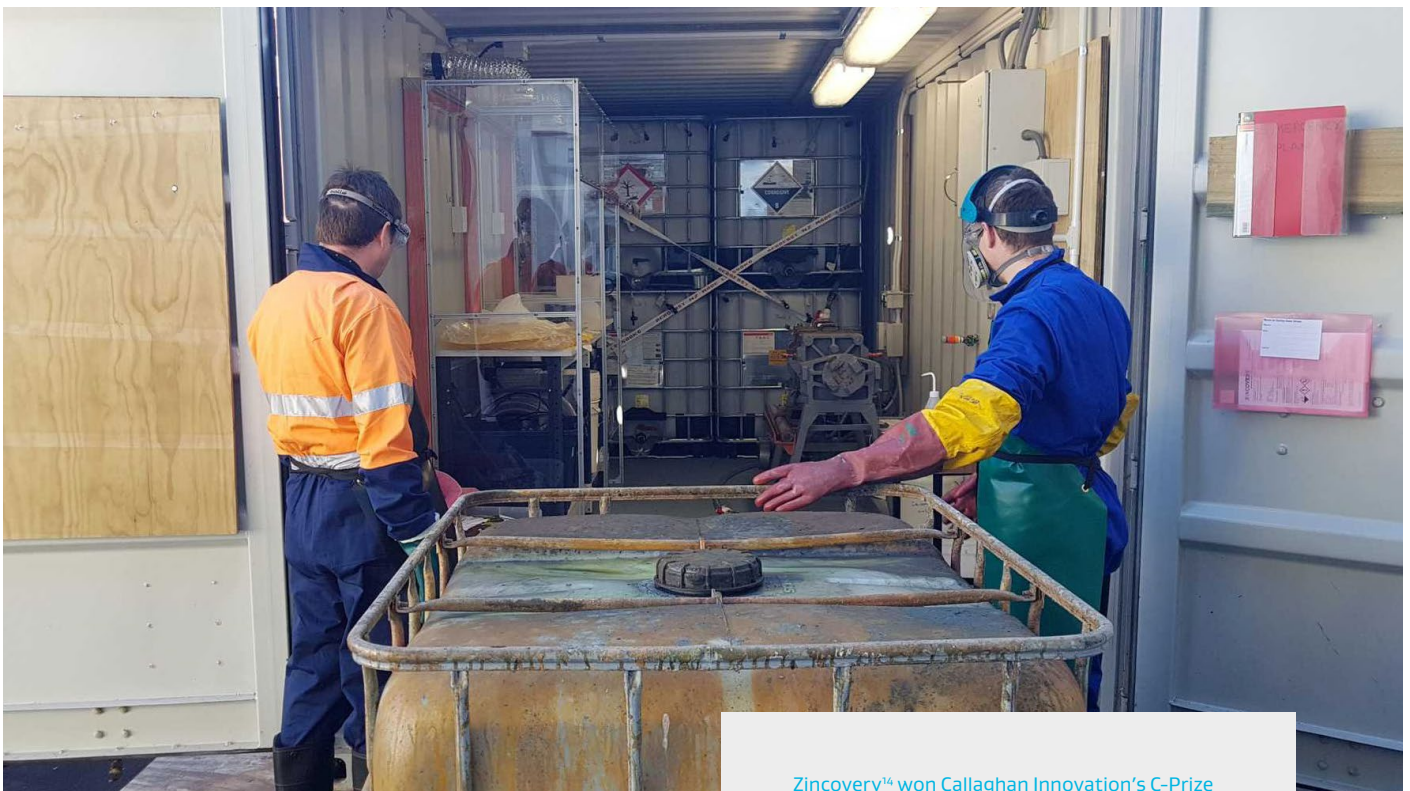
“I tried some unconventional methods and had great success. I used an electrochemical method to separate the iron and zinc at low cost, then applied existing technology to regenerate the acid. The transformation from foul green soup to a vial of clean water and metal was almost comical.”

Feedback from local galvanising industries was positive but highlighted the need to scale up to a pilot plant. This required Zincovery to employ three new engineers in 2021 who are now making serious inroads into the remaining technical challenges.

“What we’re doing here in New Zealand is proving the technology. The opportunities to export the tech and license the intellectual property are huge. The 11 galvanising plants in this country produce about 1.5 tonnes of waste acid per year. That’s about the size of a very small plant in China, where there are 4,000–5,000 galvanising plants.”

Jonathan says more stringent environmental regulations have been favourable from a business perspective by pushing up the cost of disposal. He is also intrigued by the glamour around the circular economy and recycling waste.

“When you get your overalls on, however, handling waste is not quite so pretty – for us its toxic, corrosive chemicals. But I wouldn’t have it any other way. I’m pleased to be able to do something to make a real difference in the world.”



Galvanising waste acid being loaded into the pilot plant

Zincovery¹⁴ won Callaghan Innovation’s C-Prize worth \$100,000 in 2019/20. It also received \$500,000 from MBIE’s PreSeed Accelerator Fund¹⁵ to build a pilot plant. Jonathan would like to acknowledge support from ThinLab¹⁶ and Dr Aaron Marshall, University of Canterbury.

14. www.zincovery.com/ 15. www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/preseed-accelerator-fund/ 16. www.canterbury.ac.nz/business/uce/thinlab/

CHAPTER 4

Whakapakari hononga

Strengthening connections

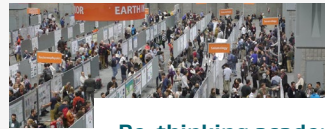
Kei roto i tēnei wāhanga

In this chapter

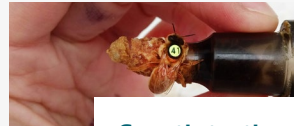
- 4.1 Te tūhonohono i roto i te hapori rangahau Connectivity within the research community 50
- 4.2 Te whakatipu mahi ngātahi rangahau ā-ao Growing international research collaborations 53
- 4.3 Te whakatipu tūhonohono rangahau me ngā pakihi Growing research connectivity with business 58
- 4.4 Te whakatipu pakihi e kōkiri ngātahi ana i te auahatanga Growing business to business collaboration on innovation 60
- 4.5 Te whakanui i te haumi haupū ā-ao ki te R&D i Aotearoa Increasing international capital investment in NZ R&D 62

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Case studies



Re-thinking academic conference travel to reduce emissions → 56



Genetic testing and breeding to improve our honeybees → 64

Kupu whakataki Introduction

Building strong connections is important in many aspects of research, science and innovation activity: within New Zealand's research community, between researchers and end-users, and with other experts, business communities and markets internationally. Connecting with researchers, scientists and innovators in the rest of the world keeps New Zealand abreast of the global knowledge and technology frontier.

Building connectivity is essential for growing the excellence and impact of our research and innovation activities. Stronger connections allow a smoother and easier flow of people, knowledge, capabilities, funding and capital across the system. More diverse connections also increase the chance of new ideas being generated. Weak connections reduce the flow of capital to support the development of innovations within New Zealand. They also

separate us from key sources of ideas and technology that help New Zealand stay at the global frontier.

The topics in this theme consider the strength of the connections between researchers, between research and business and between innovative businesses and sources of investment capital.

Ngā miramira wāhanga Chapter highlights

There is potential for New Zealand businesses to connect with each other as well as with international firms, to gain knowledge and expertise to support innovation.

Engagement in research and innovation has expanded to a variety of connections across individuals, institutes and countries.

Business-to-business collaboration on innovation is minimal and occurs more often in larger businesses.

International co-authorship rates have increased by 16 per cent since 2008. Across all fields of research, the citation performance of New Zealand publications with international collaboration now significantly exceeds those that do not.

The number of New Zealand publications with more than one author has increased. This is consistent with international trends.

4.1 Te tūhonohono i roto i te hapori rangahau

Connectivity within the research community

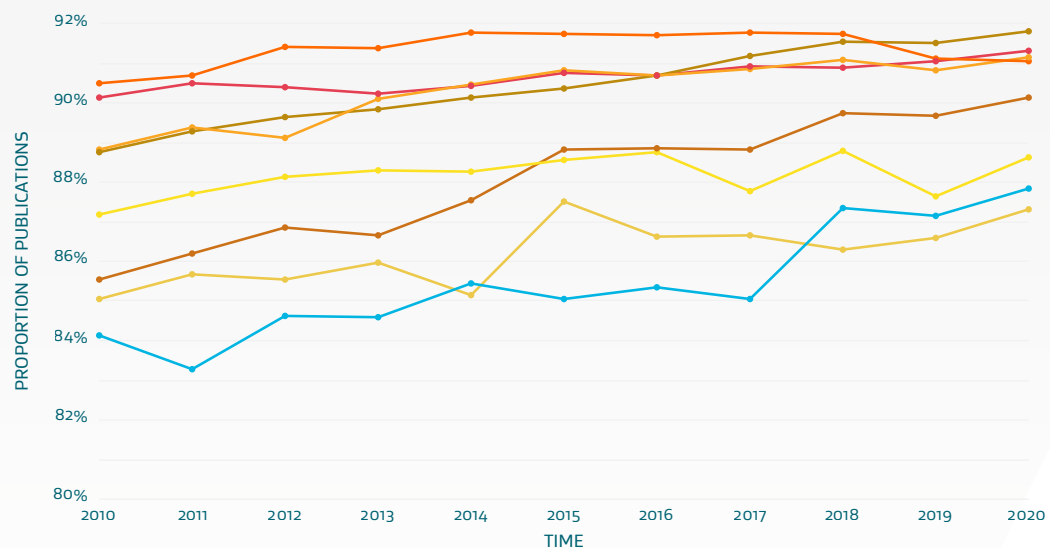
FIGURE 28

Proportion of publications with more than one author

Co-authorship is evidence of collaborative research. A number of studies have shown that collaboration between researchers is associated with higher quality research and greater citation impact (the number of times a publication is cited by subsequent publications).

Average co-authorship rates for New Zealand-affiliated publications increased by 3.7 per cent between 2010 and 2020. Rates are broadly similar across small advanced economies, ranging from 87 to 91 per cent in 2020. Although New Zealand is near the bottom of this range, co-authorship rates have increased and kept up with the increases observed in other small advanced economies.

Compared to the rest of the world, there is an opportunity for New Zealand researchers to grow connections with each other and with international partners. Building these connections provides a way for researchers to share knowledge and expertise, which can result in higher quality publications.



Data source:

Dimensions bibliometrics data See page 100

Country/region

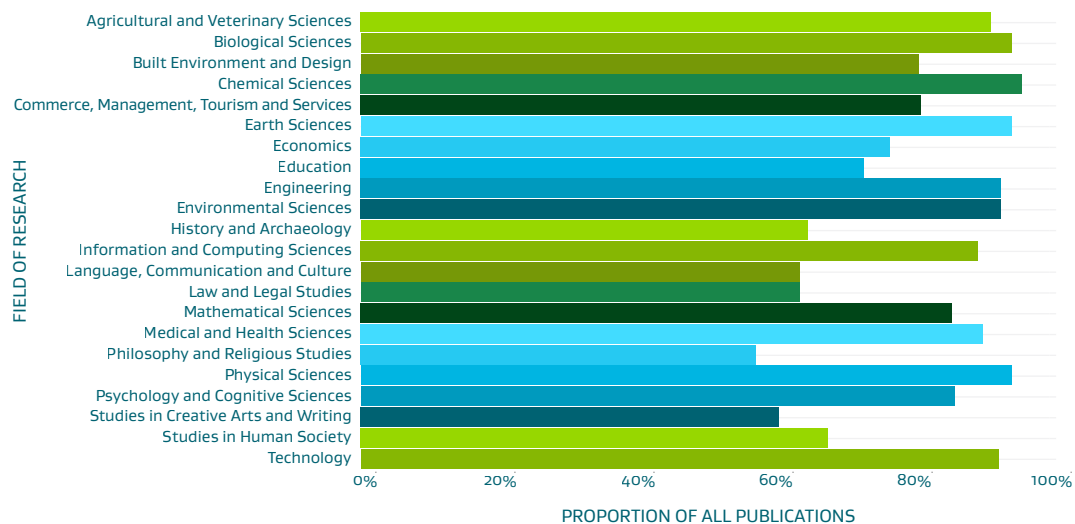
- Denmark
- Switzerland
- Finland
- Singapore
- Australia
- Ireland
- New Zealand
- Israel

FIGURE 29

Proportion of publications with more than one author by field, 2020

Collaboration on authorship is greater than 85 per cent for publications in science (ie physical, chemical, environmental, Earth, biological, agriculture and veterinary sciences) and engineering. It is lowest in fields such as history and archaeology, studies in creative arts and writing, language, communication and culture and philosophy and religious studies.

There is a trend towards increased co-authorship in all fields of research. This is likely to reflect the increased value placed on collaboration by research institutions and funders that seek to increase the impact of their research outputs.



Data source:

[Dimensions bibliometrics data](#) See page 100

Fields of research are based on the ANZSRC 2-digit classification. Dimensions categorises all publications to one or more research fields.

FIGURE 30
Effect of external co-authorship on publication impact by field, 2019

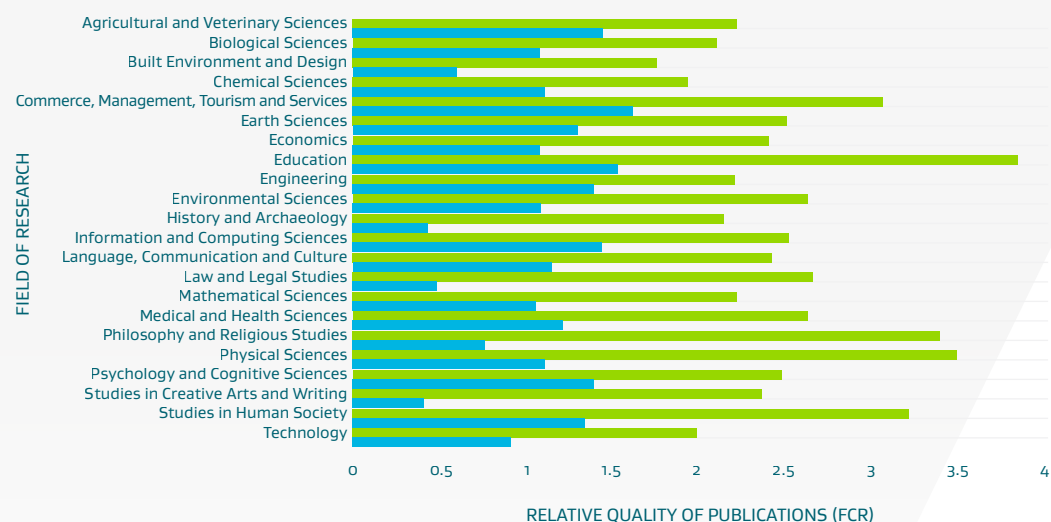
External co-authorship occurs when more than one author and more than one institution are involved in producing a publication, regardless of the co-authors' countries of origin.

The effect of external co-authorship can be observed by comparing the field citation ratios (FCRs) of New Zealand publications with no co-authorship to publications with external co-authorship in various research fields.

In all fields of research, the FCRs from publications with external co-authorship were substantially higher than those without co-authors. On average, a 2.7-fold increase in FCR was seen in publications involving external co-authorship. This ranged from a 1.5-fold increase in agricultural and veterinary sciences to a 5.7-fold increase in studies in creative arts and writing.

The fields of research where FCR was most influenced by external co-authorship for 2019 were:

- studies in creative arts and writing (2.4 vs 0.4)
- law and legal studies (2.6 vs 0.5)
- history and archaeology (2.1 vs 0.4)
- philosophy and religious studies (3.4 vs 0.8).



Data source:

[Dimensions bibliometrics data](#) See page 100

The field citation ratio (FCR) is a citation-based measure of scientific influence of one or more articles. It is calculated by dividing the number of citations a paper has received by the average number of citations received by documents published in the same year and in the same field of research. Fields of research are based on the ANZSRC 2-Digit Classification. Dimensions categorises all publications to one or more research fields.

Collaboration

- Collaboration
- No collaboration

4.2 Te whakatipu mahi ngātahi rangahau ā-ao

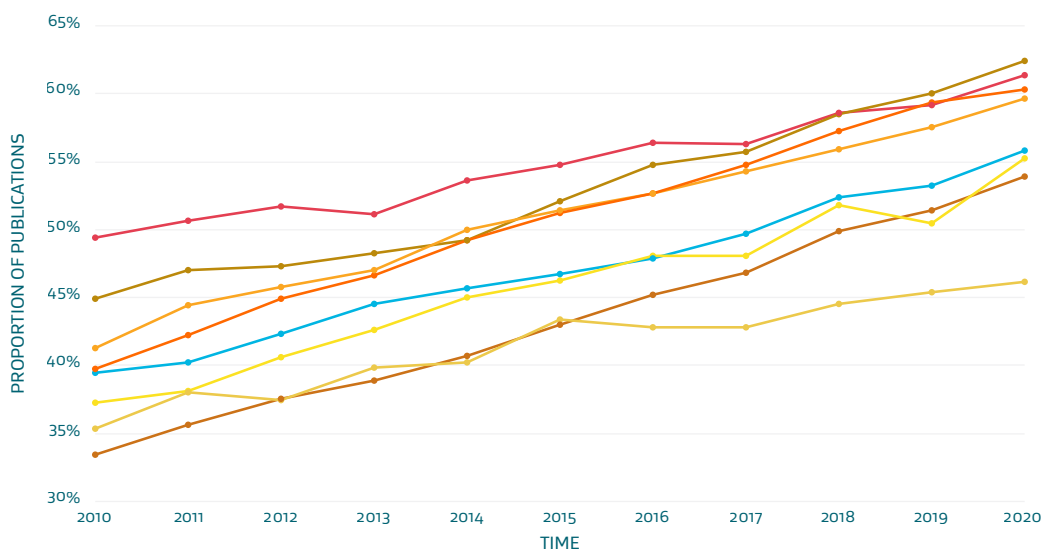
Growing international research collaborations

FIGURE 31

Proportion of publications with international co-authorship

Connectivity with international researchers is essential for growing both the quality and impact of New Zealand research. Publications with international co-authorship are cited more frequently.

The proportion of publications with international collaboration is increasing across all small advanced economies and Australia. New Zealand is on a par with these countries, with nearly 56 per cent of publications having international co-authors in 2020, up from 39 per cent in 2010.



Data source: Dimensions bibliometrics data See page 100

Country/region

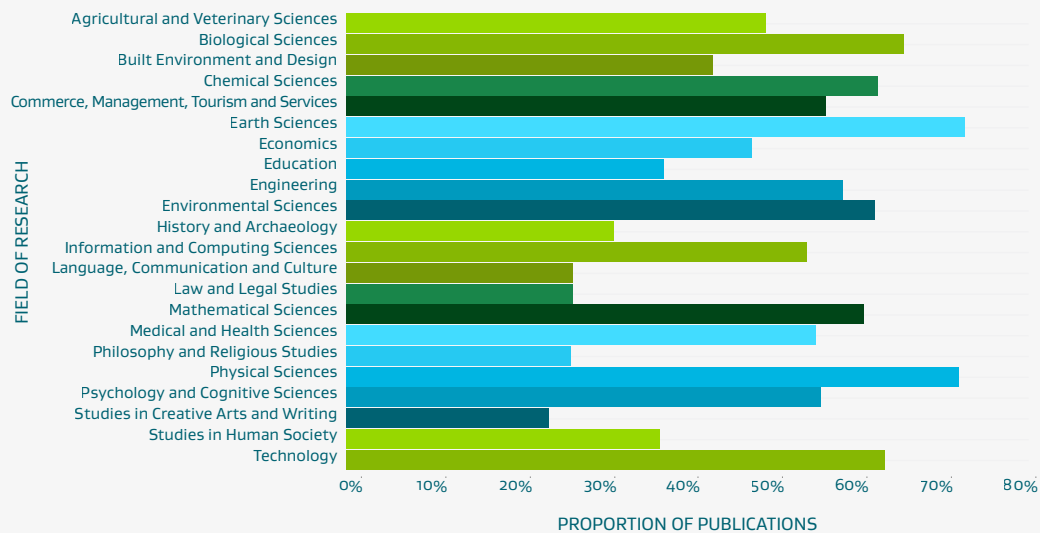
- Denmark
- Switzerland
- Singapore
- Finland
- New Zealand
- Ireland
- Australia
- Israel

FIGURE 32

Proportion of publications with international co-authorship by field

International collaboration rates vary by field of research. In 2020, collaboration rates were highest in Earth sciences (73%), physical sciences (73%), biological sciences (66%), technology (64%), chemical sciences (63%), environmental sciences (63%) and mathematical sciences (61%).

The rates were much lower for fields such as studies in creative arts and writing (24%), philosophy and religious studies (27%), law and legal studies (27%) and language, communication and culture (27%). Note that collaboration rates (ie publications with more than one author) were also generally lower in these fields (see figure 29).

**Data source:**

Dimensions bibliometrics data See page 100

Fields of research are based on the ANZSRC 2-digit classification.
Dimensions categorises all publications to one or more research fields.

International science and innovation partnerships

Partnerships enhance connections between New Zealand's science system and the rest of the world. The Singapore-New Zealand Enhanced Partnership was signed in 2019 and seeks to lift cooperation in science, innovation, trade and security between the two countries.

MBIE has committed \$22.3 million over 3 years to this partnership, supporting joint research programmes related to data science and future foods. Agreed priority areas are health, natural language processing, three-dimensional environmental sensing and non-animal food protein.

[Read more¹](#)

1. www.mbie.govt.nz/science-and-technology/science-and-innovation/funding-information-and-opportunities/investment-funds/catalyst-fund/

FIGURE 33

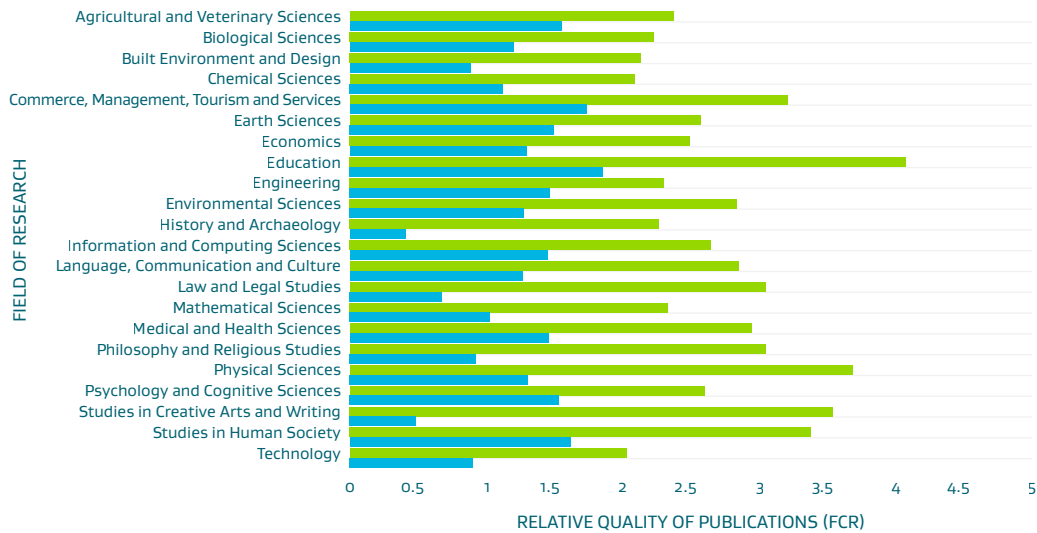
Effect of international collaboration on publication impact by field

Across all fields of research, the citation performance of publications with international co-authorship substantially exceeded the citation performance of publications without. On average, a 2.6-fold increase in the field citation ratio was seen in publications with international collaboration compared with those without. This ranged from a 7.3-fold increase in studies in creative arts and writing to a 1.5-fold increase in agricultural and veterinary sciences.

In 2019, the fields with the largest difference were:

- studies in creative arts and writing (3.5 vs 0.5)
- physical sciences (3.7 vs 1.3)
- law and legal studies (3.1 vs 0.7)
- education (4.1 vs 1.9).

Engagement with international colleagues is universally associated with higher uptake of research, as measured by citation rates. Growing international collaboration is one pathway to increased uptake of New Zealand research.



Data source:

[Dimensions bibliometrics data](#) See page 100

Collaboration

- International collaboration
- With no international collaboration

Field citation ratio (FCR) is a citation-based measure of scientific influence of one or more articles. It is calculated by dividing the number of citations a paper has received by the average number received by documents published in the same year and in the same fields of research. Fields of research are based on the ANZSRC 2-digit classification. Dimensions categorises all publications to one or more research fields.



CASE STUDY

RE-THINKING ACADEMIC CONFERENCE TRAVEL TO REDUCE EMISSIONS

American Geophysical Union poster hall. Credit Josh Wood

James Higham, Professor of sustainable tourism, University of Otago

Sitting on a plane at Heathrow Airport after a conference in England was a wake-up moment for James Higham. In contrast to previous conferences that had been beneficial for his career, he realised that this one had been a waste of time, money and carbon.

“That experience made me very selective – I’ve barely attended a conference in the last 15 years. I’ve discovered there are better ways to use my limited time and resources and more inclusive and equitable ways of disseminating research.”

In 2014 he initiated a research programme with colleague Dr Debbie Hopkins to research the culture of academic flying at the University of Otago. As well as policy analysis, they carried out interviews with a diverse range of colleagues to find out why they flew and why they may have chosen not to.

“That confirmed the personal and professional benefits of attending academic conferences, presenting papers, and networking. But air travel also represents

an enormous contribution to our carbon footprint and that was something many were finding increasingly difficult to ignore.”

This year their collaboration extended to a project (led by Milan Klöwer, a colleague of Debbie’s at the University of Oxford) that was published in *Nature* in July 2020. It presented ways to slash the carbon footprint of academic conferences, using the Fall Meeting of the American Geophysical Union as a model.

“The 28,000 delegates were calculated to have travelled 285 million kilometres and emitted an eye-watering 80,000 tonnes of CO₂ in flying to attend. (This is about the same as a large city like Edinburgh emits in a week.) The majority of emissions were from inter-continental flights.”

The authors proposed an alternative model with centrally located and virtually linked hubs in Europe, Asia and North America. This, along with increasing virtual attendance and biennial rather than annual meetings, could reduce the transport emissions of future conferences by up to 91 per cent.

James is not suggesting that academics stop flying to conferences altogether. "Living and working in Aotearoa New Zealand makes that an unrealistic and undesirable proposition. Our argument is that taking long-haul flights to attend annual conferences is grossly unsustainable."

He proposes that academics attend virtual conferences regularly, and try to fly much less frequently but stay abroad for longer periods.

"This 'research and study leave' model allows time overseas to engage in field work, conferences, networking, collaboration, writing and publication – all of those very good things."

Earlier this year when COVID struck, conferences were suddenly cancelled, postponed or moved online. When the European Geosciences Union meeting moved online, the number of delegates increased from 16,000 to 22,000, including attendees from 28 previously unrepresented countries.

"Interestingly, this highlighted barriers, inequities and privileges in the physical attendance model that we were either unaware of in the past, or prepared to ignore.

"The pandemic has forced us to do things differently. Although some people will want to rush back to a highflying life, if we're open, we can maximise the many possibilities that are emerging in this new environment."

Nature reference: Klöwer, M., Hopkins, D., Allen, M. & Higham, J.E.S (2020). [Decarbonising conference travel after COVID-19](https://doi.org/10.1038/s41586-020-02057-2). Nature 583: 356-360.



Professor James Higham

4.3 Te whakatipu tūhonohono rangahau me ngā pakihi

Growing research connectivity with business

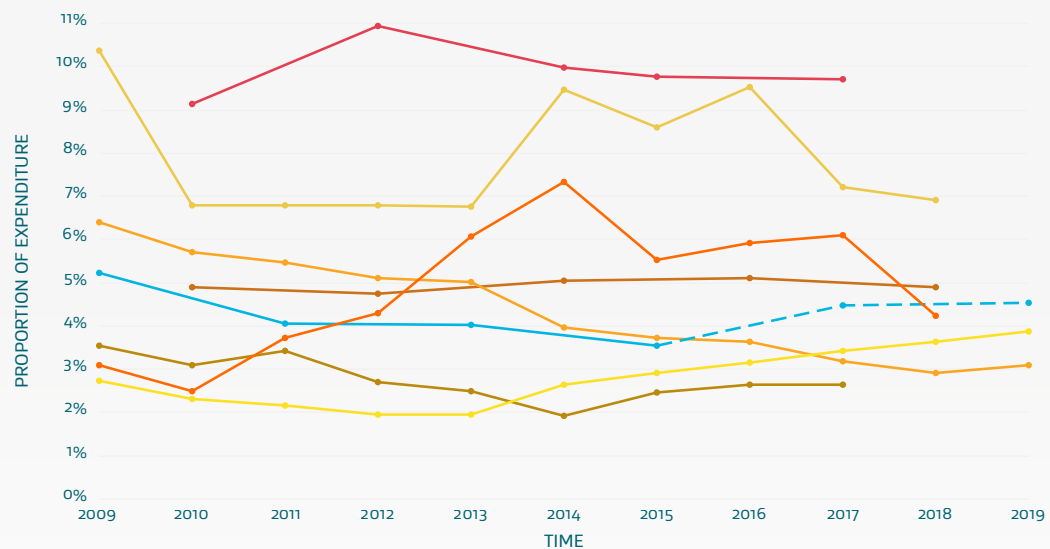
58

FIGURE 34

Proportion of higher education expenditure on R&D funded by business

Evidence shows that research in universities that is funded at least in part by business has substantially higher economic impact, as measured by the proportion of inventions that are patented or licensed.

From 2009 to 2019, R&D undertaken by universities and funded by business remained about 4–5 per cent of higher education R&D expenditure. This is despite the overall 35 per cent increase in total funding in higher education for the same time period (see [section 1.6](#)).



Data source:

OECD research and development statistics See page 101

Stats NZ research and development survey See page 101

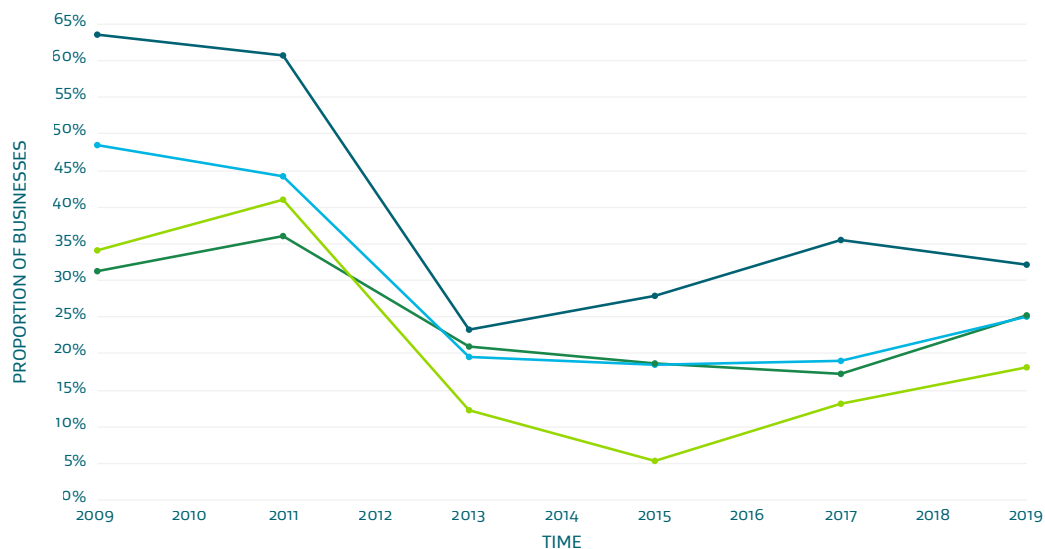
Country/region

- Switzerland
- Israel
- Australia
- New Zealand
- Singapore
- Ireland
- Finland
- Denmark

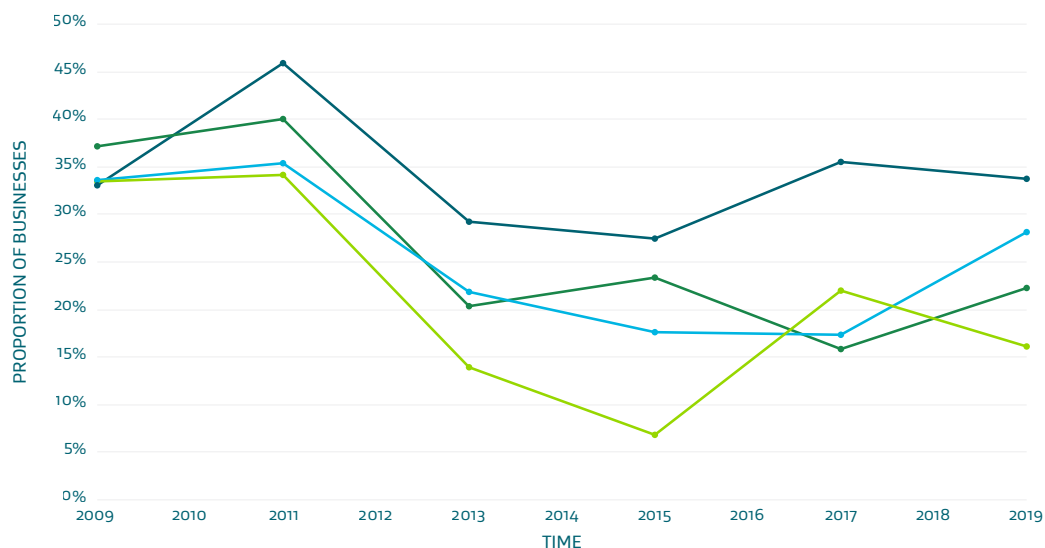
FIGURE 35
Proportion of businesses cooperating with research organisations for innovation, by business size

The business operations survey queries businesses about cooperation with research organisations for innovation. There was a reduction in the level of business cooperation with universities, Crown research institutes and other research organisations in 2013. This corresponds to the timing of agency changes including the disestablishment of Industrial Research Limited and the establishment of Callaghan Innovation as the main government agency supporting businesses innovation. Levels of business cooperation had generally not recovered from 2009 levels by 2019.

Crown research institutes



Universities or polytechnics



Data source:
Stats NZ business operations survey See page 101

Business size by number of employees

- 6-19
- 20-49
- 50-99
- 100+

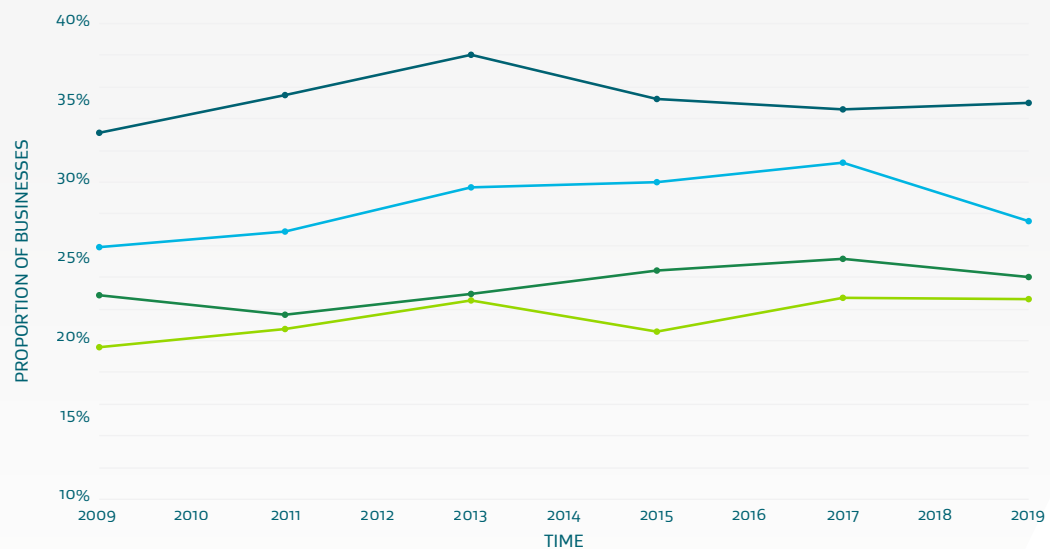
4.4 Te whakatipu pakihi e kōkiri ngātahi ana i te auahatanga Growing business to business collaboration on innovation

FIGURE 36

Proportion of businesses cooperating on innovation, by business size

Business-to-business cooperation on innovation includes cooperation with suppliers, customers and other businesses, as well as research organisations. While businesses may naturally resist sharing ideas to protect their intellectual property, there are substantial gains to be made from seeking complementary knowledge and pooling resources and expertise across firms.

In general, business-to-business cooperation on innovation is more common in larger firms (ie 100+ employees). Since 2009, this type of cooperation has increased only marginally in businesses with fewer than 100 employees.



Data source:

Stats NZ business operations survey See page 101

Business size by number of employees

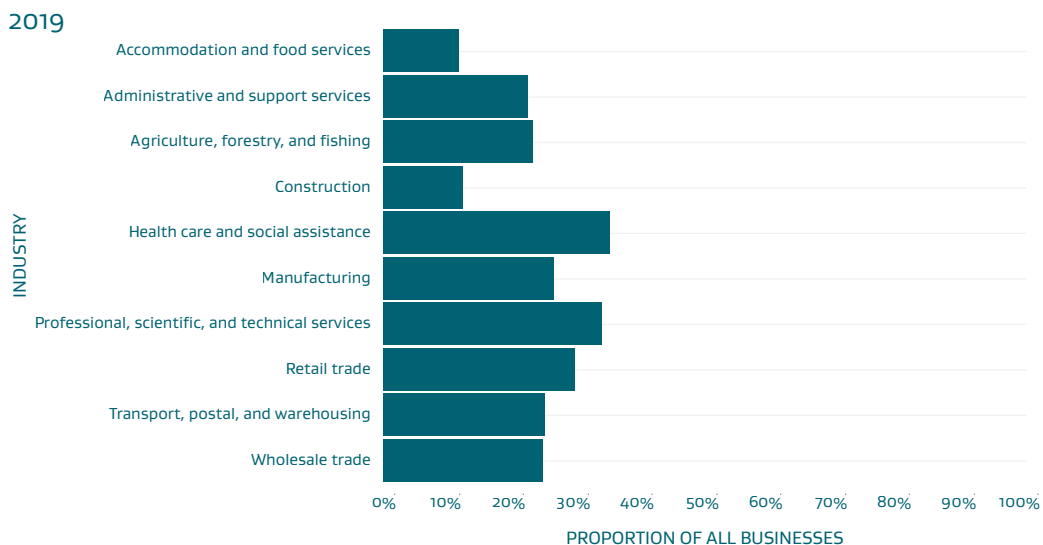
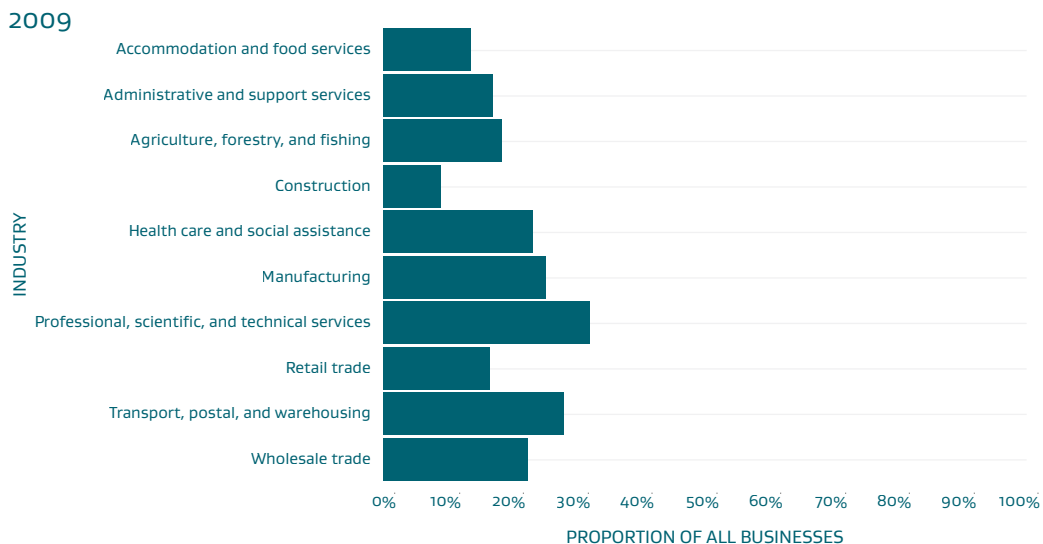
- 6-19
- 20-49
- 50-99
- 100+

FIGURE 37

Proportion of businesses cooperating on innovation, by industry

Cooperation for innovation occurred in 21–26 per cent of businesses between 2009 and 2019. Industry-specific rates have, however, been quite variable over this period.

For larger industry groups (ie those with more than 500 businesses) in 2019, the most cooperation for innovation occurred in healthcare and social assistance (35%), professional, scientific and technical services (34%), retail trade (30%) and manufacturing (26%).



Data source:
Stats NZ business operations survey See page 101

4.5 Te whakanui i te haumi haupū ā-ao ki te R&D i Aotearoa Increasing international capital investment in NZ R&D

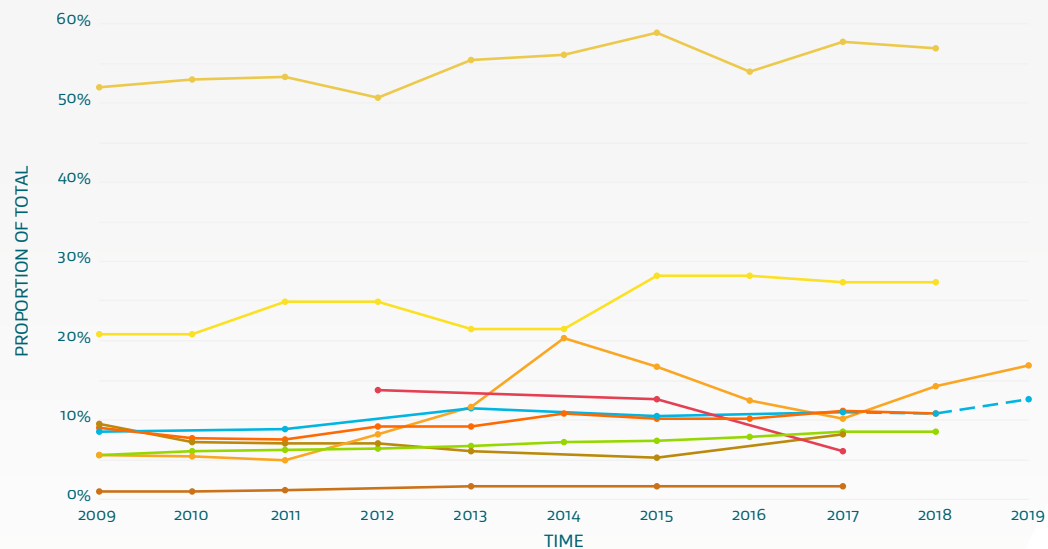
62

FIGURE 38

Proportion of business expenditure on R&D financed from overseas

Stronger international connections will help New Zealand access knowledge and solutions that are available elsewhere and address some of this country's challenges. Growing connectivity to international firms, markets and capital is also essential for growing the scale of New Zealand's start-up businesses.

Between 2009 and 2019, the proportion of funding from international sources for business R&D was above the OECD- Totals and similar to most small advanced economies (apart from Israel and Ireland). The proportion of funding from international sources for business R&D in New Zealand increased from 8.5 to 12.7 per cent during this period.



Data source:

OECD main science and technology indicators See page 101

Stats NZ research and development survey See page 101

Data for business expenditure comes from the research and development survey. The figures include spending by businesses, universities, CRIs and government agencies. The OECD- Total offsets New Zealand data by 1 year so it can be compared to other countries.

Country/region

- Israel
- Ireland
- Finland
- New Zealand
- Singapore
- OECD - Total
- Denmark
- Switzerland
- Australia

Centres of Research Excellence

The Centres of Research Excellence (CoREs) Fund was established in 2001 to encourage the development of tertiary education-based research. CoREs operate across different organisations and allow researchers to work together on agreed programmes. They support training and the development of world-class researchers in areas that are important for New Zealand's future.

Funding is awarded through a fully contestable process. The 10 CoREs funded to June 2021 were Bio-Protection Research Centre, Brain Research New Zealand, Dodd-Walls Centre, MacDiarmid Institute for Advanced Materials and Nanotechnology, Maurice Wilkins Centre, MedTech CoRE, Ngā Pae o te Māramatanga, QuakeCoRE, Riddet Institute and Te Pūnaha Matatini.

The 10 CoREs funded to December 2028 are Bio-Protection Aotearoa, Coastal People: Southern Skies, Dodd-Walls Centre, Te Whai Ao, Ngā Pae o te Māramatanga, Te Hiranga Rū QuakeCoRE: Aotearoa New Zealand Centre for Earthquake Resilience, Riddet Institute, Te Pūnaha Matatini, MacDiarmid Institute for Advanced Materials and Nanotechnology and Maurice Wilkins Centre.

The [CoRE Fund](#)³ is administered by the Tertiary Education Commission.

Callaghan Innovation

The government set up Callaghan Innovation in 2013 to support business R&D and accelerate commercialisation in New Zealand.

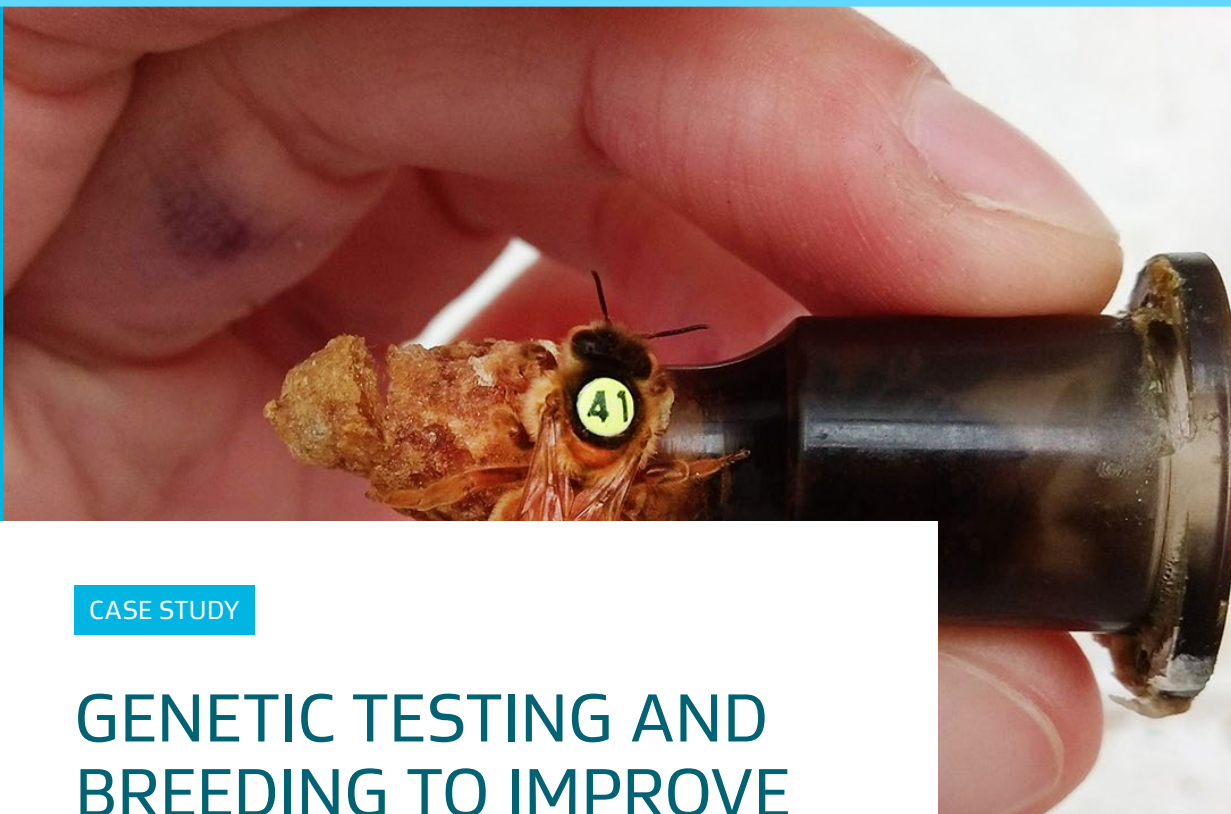
The agency has a mandate to increase business investment in R&D. It does this by challenging companies to create or improve their R&D programmes, administering the R&D Tax Incentive and granting funding. It also offers technical expertise and equipment to support R&D activity.

Sir Paul Callaghan, for whom the agency is named said, "One hundred inspired entrepreneurs can turn this country around. That is the challenge for all of us."

[Read more](#)⁴

3. www.tec.govt.nz/funding/funding-and-performance/funding/fund-finder/centres-of-research-excellence/

4. www.callaghaninnovation.govt.nz/



CASE STUDY

GENETIC TESTING AND BREEDING TO IMPROVE OUR HONEYBEES

A newly hatched queen bee

Peter Dearden, Professor, University of Otago

Understanding the genetics of bees has been in the 'too-hard' basket for years. Queen bees mate with multiple males a kilometre in the air, bees live together as a super-organism and the genetics themselves are just plain weird.

But the importance of having the best possible bees for pollination and honey production is indisputable.

"New Zealand's sheep and cattle breeding industries have made enormous gains by selective breeding. They keep bringing out new genomic tools to improve the way they do it. I thought it was about time to do the same for bees because of the value of the honey industry – mānuka in particular."

The multidisciplinary FutureBees team includes biomathematicians, insect scientists, ecologists, bee breeders and honey producers from around the country.

"The point isn't to set up a bee breeding programme that we continue to run, but to give beekeepers the tools to do it themselves. After 5 years we plan to have done the hard bits and produced a useful decision-making tool."

Peter envisions that each year beekeepers would sample a hive, get the genomes sequenced (current cost is about \$40 per bee), then dial up a new queen bee to improve the genetics of their hives.

"We're putting in a very technical programme but that needs to sit behind a simple, accessible, mobile interface – most beekeepers didn't go into the industry to sit behind a computer."

The direction of the programme is guided by beekeepers around what they value, like honey production and disease resistance. Remote monitoring tools are of great interest because hives are usually dotted around a region and visited about once a month.

“Tools like the weight of a hive and bee activity can provide up-to-date data on how the hive is doing. If there’s a problem you’ll know about it straight away, so that’s an immediate productivity benefit.”

The really clever bit is taking that information and other environmental data (like weather conditions) and linking it to hive genetics using statistical methods.

“We imagine FutureBees will also create demand for new queens and grow that industry, but with better control over the genetics.”

The team’s research to date has found that New Zealand bees have good genetic diversity and that no particular traits are needed for bees to be good pollinators over honey producers.

“We do need to worry very much about inbreeding. Improving bee stocks and maintaining genetic variation are absolutely opposed, so we have to manage that. But bees move around, so your breeding actually improves those in an entire area.”

Peter says working closely with communities and end users is a vital part of the programme. He has some advice for all scientists.

“If you want to have an impact, make sure you’re talking with the right people and doing a lot of listening. I’ve been working with beekeepers since 2004 and am more and more impressed with their remarkable knowledge and skill. Science is very good at ignoring all of that. I hope we’re now starting to show that we have some skills and technologies that could help them.”

[FutureBees⁵](#) is an Endeavour-funded research programme and includes collaborators from the University of Otago, AbacusBio, AgResearch, Cawthron Institute, Plant & Food Research, Betta Bees Research Limited, Midland Apiaries, Ngati Porou Miere, Tai Tokerau Honey and Taylor Pass Honey Company.



Professor Peter Dearden

5. www.futurebeesnz.wordpress.com/who-we-are/

CHAPTER 5

Tautoko hiranga

Supporting excellence

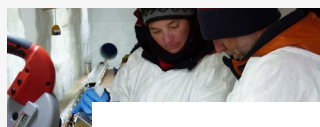
Kei roto i tēnei wāhanga

In this chapter

- 5.1 Ngā kairangahau kei te haputa o tō rātou papa rangahau Researchers at the forefront of their field 68
- 5.2 Te whakakaha i te aweawe me te kounga o te rangahau Improving the influence and quality of research 69

He mātai take

Case studies



New Zealand Ice Core Research Facility → 70



COVID-19 models inform government responses → 72

Kupu whakataki Introduction

Research, science and innovation are global endeavours, so knowledge, techniques, standards and products can only be considered 'excellent' when viewed in a global context. A characteristic of excellence is that the activities are in line with the best technology, people and ideas internationally.

Excellence in innovation means growing, attracting and retaining the best visionary thinkers, entrepreneurs, investors and firms. This is true for our public services as much as our innovative businesses.

People are the critical determining factor, so diversity is vital. New Zealand can only maximise the excellence of its activity if diverse talent is able to thrive in the research, science and innovation system. (See [chapter 7](#) for information about the size, diversity and pipeline of the research workforce.)

This chapter examines the extent to which New Zealand researchers are at the forefront of their fields, when compared with the international research community.

Ngā miramira wāhanga Chapter highlights

The proportion of New Zealand publications in the top 1 per cent of the most cited publications worldwide in all research fields increased from 2.0 to 2.7 per cent between 2010 and 2019.

In 2019, the highest volume of New Zealand publications in the top 1 per cent were in **language, communication and culture (6% of top 1% publications).**

Relative to all publications in their respective fields, **New Zealand has produced highly cited research (publications with greater impact) in physical sciences, commerce, management, tourism and services, and education.**

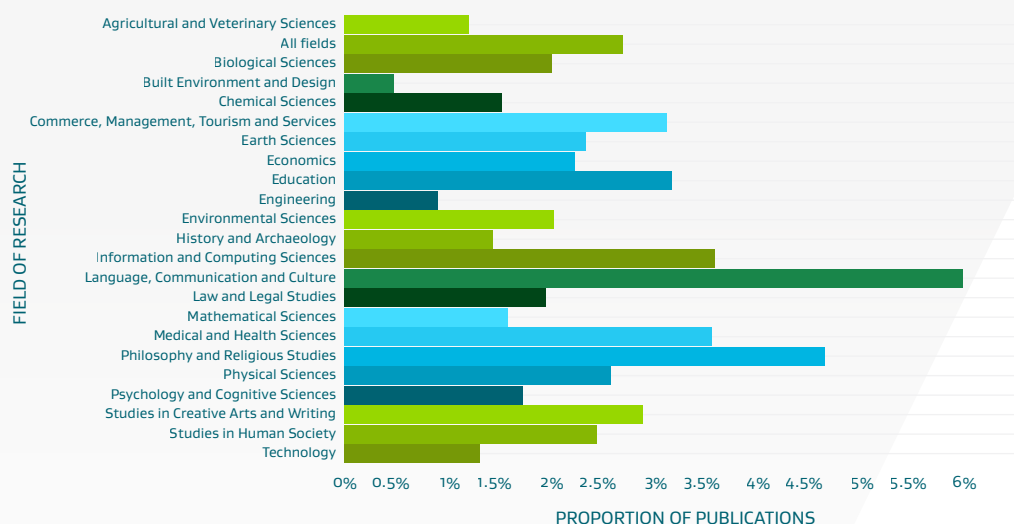
5.1 Ngā kairangahau kei te haputa o tō rātou papa rangahau Researchers at the forefront of their field

FIGURE 39

Proportion of New Zealand-based publications in the top 1% of world research, by field

The quality of research in New Zealand has been improving since 2010, based on the proportion of publications in the top 1 per cent worldwide by field of research.

In 2019, 2.7 per cent of New Zealand-affiliated publications were in the top 1 per cent of most cited publications globally. This was an increase from 2.0 per cent in 2010. The highest volume of publications in the top 1 per cent of most cited publications were in the fields of language, communication and culture (6%), philosophy and religious studies (5%), information and computing sciences (4%), and medical and health sciences (4%).



Data source:

[Dimensions bibliometrics data](#) See page 100

A field of research is assigned to every publication with New Zealand-affiliated authors using the [Australian and New Zealand Standard Research Classification](#)¹. The data presented is for publications in these research fields in 2019.

1. www.arc.gov.au/grants/grant-application/classification-codes-rfcd-seo-and-anzsic-codes

5.2 Te whakakaha i te aweawe me te kounga o te rangahau Improving the influence and quality of research

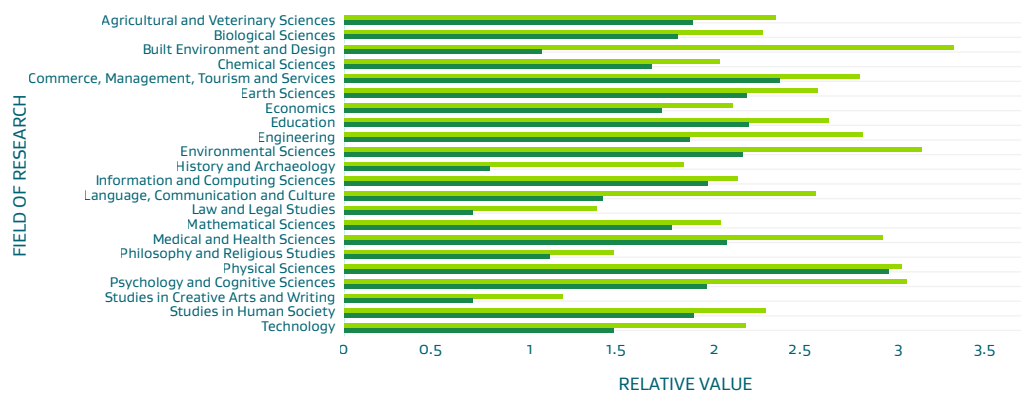
FIGURE 40
Volume and quality of New Zealand research, by field

Highly cited research occurs in all fields of study, including those that are less prominent in New Zealand than the rest of the world. The relative quality of New Zealand publications (measured by the mean field citation ratio, FCR) declined between 2010 and 2019 but remains twice the world average (FCR 1.94).

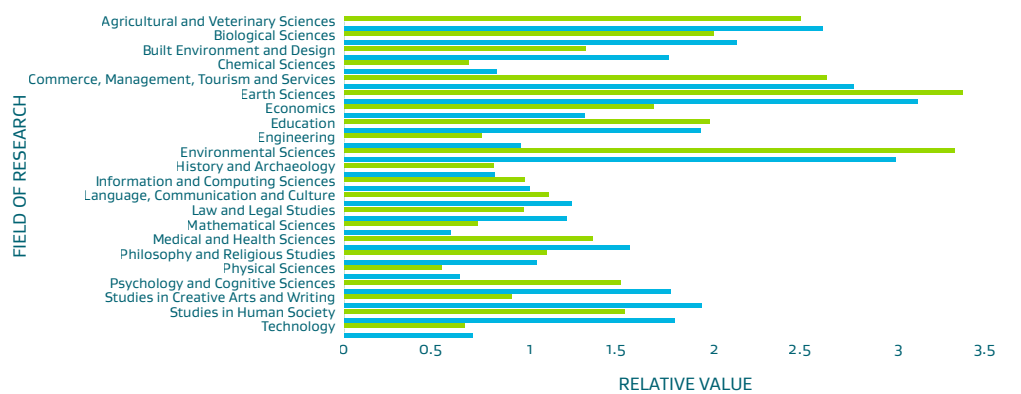
In 2019, physical sciences (FCR 2.95), commerce, management, tourism and services (FCR 2.36), and education (FCR 2.19) were the fields with the highest FCRs.

The specialisation of New Zealand research was consistent in 2010 and 2020. Earth sciences and environmental sciences were the fields with the highest relative volume in both years as measured by the revealed comparative advantage, RCA (FCR and RCA are explained further in the figure caption).

Relative quality (FCR)



Relative volume (RCA)



Data source:
Dimensions bibliometrics data See page 100

Years

- 2010
- 2019
- 2020

The revealed comparative advantage (RCA) is the proportion of New Zealand publications in one field divided by the proportion of publications in the same field globally. The field citation ratio (FCR) is a citation-based measure of scientific influence of one or more articles. It is calculated by dividing the number of citations a paper has received by the average number received by documents published in the same year and in the same field of research category. A field of research is assigned to every publication (with New Zealand affiliated authors) using the [Australian and New Zealand Standard Research Classification](#)¹. The data in the figure is for publications in these research fields in 2010, 2019 (FCR) and 2020 (RCA).



CASE STUDY

NEW ZEALAND ICE CORE RESEARCH FACILITY

Dr Nancy Bertler (left) and a colleague processing an ice core in Antarctica

Nancy Bertler, Director, Antarctic Science Platform

The New Zealand Ice Core Research Facility allows ice cores to be processed, analysed and stored safely. This capability has enabled pioneering research in Antarctica and secured New Zealand's position as a leader in climate science.

Millennia of snowfalls record past climates in the chemistry of their ice and the tiny bubbles of air trapped with them. When an ice core is extracted, its layers can be analysed to reconstruct a story about how the climate has varied over millions of years at that particular place.

Nancy has had a central and enduring role in establishing ice core research in New Zealand. When she arrived in 1999 for her PhD studies, there was no ice core programme here, and overseas, cores were only being taken from the interior of Antarctica.

"Until we started looking at the coastal regions, no one thought ice cores from there would be useful. We figured their position would make them really sensitive to interactions between the ocean, the ice sheet and the atmosphere."

Her hunch proved to be correct and the Ross Sea region, where New Zealand has guardianship, turned out to be perfect for this new application.

"It's a challenging environment but it gave us a niche to do some really important research. From that we made a case that we needed a facility here to do the work, rather than continuing to ship cores to our overseas collaborators."

New Zealand's high-tech ice core research facility was built in 2007 and is 1 of only 20 worldwide. Keeping the cores below -18°C degrees is essential to prevent deterioration and changes in the ice. This mandates a secure refrigeration system with power backups, a low-moisture environment and ultraclean facilities to protect the ice from contamination. A suite of analytical instruments is also housed in the facility.

A three-way collaboration between GNS Science, Victoria University of Wellington and NIWA established the ice core facility.

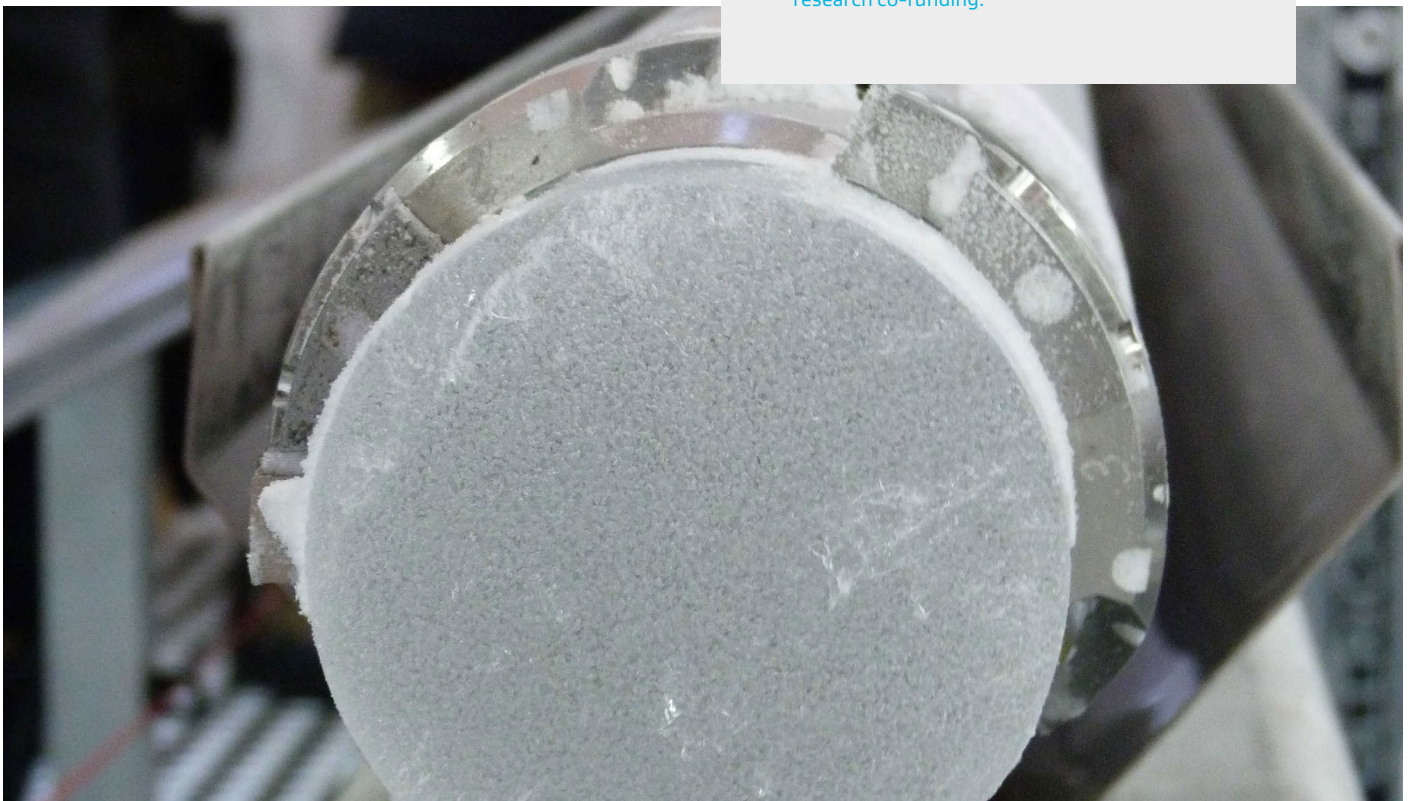
“This was a huge bonus because it gave us access to so much extra science capability. The facility’s cold conditions have also been used for research in volcanology, physics and other disciplines and provided exceptional scientific training for many postgraduate students.”

Nancy stresses the value of the ice. “There’s never enough and nothing is ever thrown away – it’s really precious. We have to push our analytical capabilities to use smaller and smaller samples. Every millilitre from a 2.5 tonne core is entered into a database and we account for every drop.”

The facility was central to the international Roosevelt Island Climate Evolution project. It set out to discern what the Paris Agreement target of keeping warming within two degrees would mean for Antarctic ice.

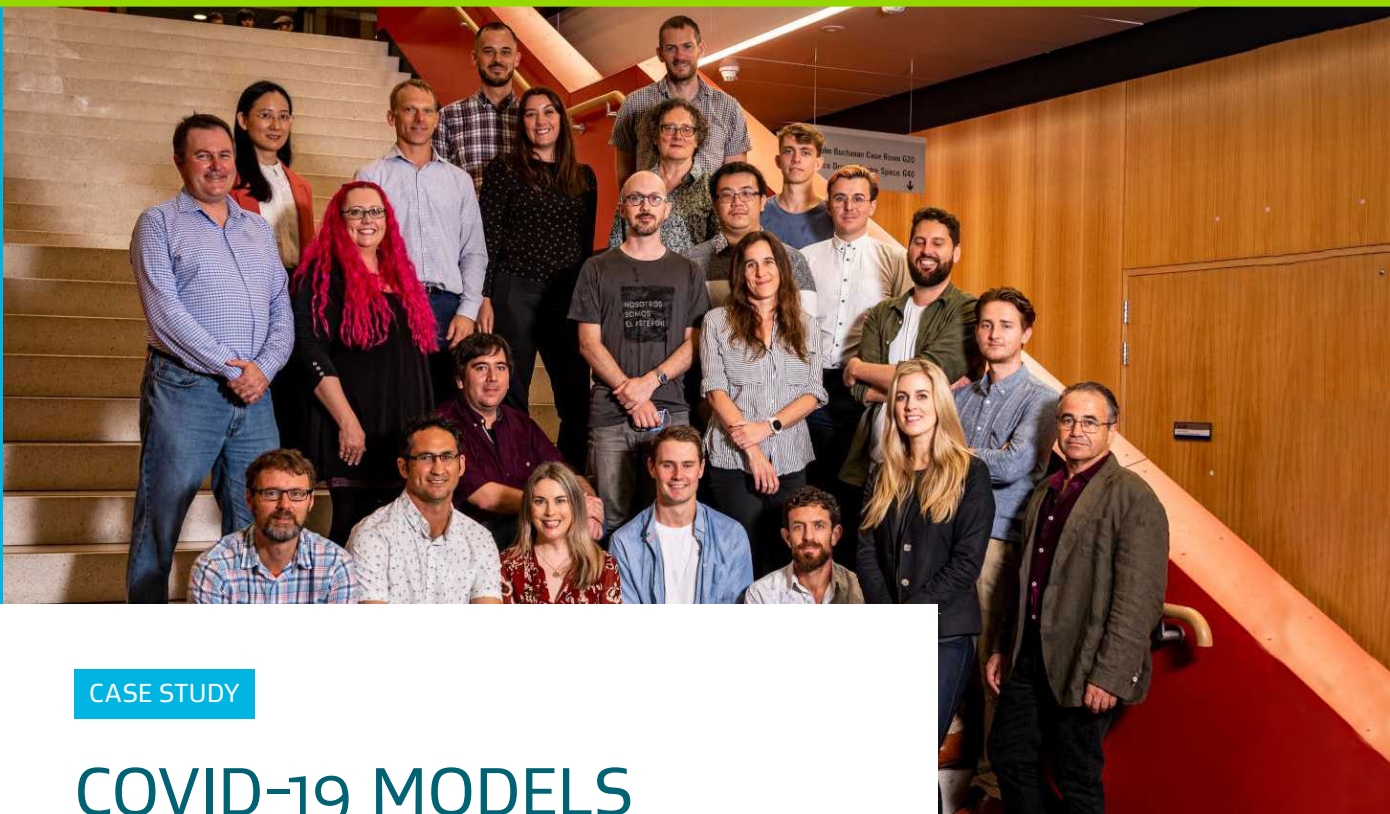
“We had to figure out if this much warming would commit us to a collapse of the Ross Ice Shelf and the West Antarctic ice sheet, and therefore significant sea-level rise. Using ice core records, we were able to see the extent of the ice shelf during a warm period 130,000 years ago when global temperature was 1–2 degrees higher than today.”

Nancy is a principal scientist at GNS Science and an associate professor of ice core paleoclimatology at the Antarctic Research Centre, Victoria University of Wellington. She is currently seconded as director of the [Antarctic Science Platform](https://www.antarctic-science-platform.org.nz/)² and is the chief scientist of the 9-nation RICE Project. Nancy was awarded a Rutherford Discovery Fellowship in 2011 and was part of the Melting Ice and Rising Seas team that won the Prime Minister’s Science Prize in 2019. The New Zealand Ice Core Research Facility is situated in Gracefield, Lower Hutt and run jointly by GNS Science, NIWA and Victoria University of Wellington. It has received funding from many sources including the Strategic Science Investment Fund, the Marsden Fund, logistics and capital expenditure support and international research co-funding.



Cross-section of an ice core, with trapped air bubbles visible

2. www.antarctic-science-platform.org.nz/



CASE STUDY

COVID-19 MODELS INFORM GOVERNMENT RESPONSES

Professor Shaun Hendy (standing at left) with the team from Te Pūnaha Matatini who contributed to the COVID-19 response. Credit: Royal Society Te Apārangi

Shaun Hendy, Principal Investigator, Te Pūnaha Matatini

Soon after COVID-19 was identified overseas, the Te Pūnaha Matatini team modelled scenarios of how the disease could spread in this country. Scenarios that showed the possibility of tens of thousands of deaths formed some of the evidence that underpinned the strong measures taken by the Government to eliminate the virus.

“We definitely weren’t planning to do this work! I ran some models in early March 2020. I could see from the size and speed of the pandemic that there was no way we were going to spend our travel budget that year. We decided to repurpose it and stood up a team of about 20 people to work on the response straight away.”

Shaun says the vision for Te Pūnaha Matatini had always been to create and foster inclusive, novel and broad collaborations. “Our centre of research excellence focusses

on complex systems. As these show up in some way in every discipline, I thought there was value in learning from how other disciplines approach them. We reached out to the humanities as well as other sciences, and created an inclusive environment that built diversity in gender and ethnicity.”

“Because of this diverse community, we were often able to anticipate policy needs during the COVID-19 response before our models became crucial for decision-making. Our strong connections with

policy as well as access to different people and knowledge systems definitely helped inform and steer our work.”

One modelling project focussed on the infection and fatality rates for Māori and Pasifika people. Although the data was sparse, the model was able to show that because of some health conditions that tend to be more prevalent in these communities, they were much more at risk than other segments of the population.

“COVID-19 could have been really devastating for kuia and kaumātua if it ever got into a Māori community. The iwi road blocks were very much informed by new evidence such as ours as well as the community’s own memories of the 1918 pandemic.”

The modelling and associated research continues to provide insights and inform decisions about vaccines, risks from new variants and options to relax border controls over time. Te Pūnaha Matatini has also created an open-source, national epidemic model and policy simulator based on the latest technology, research and data.

[Te Pūnaha Matatini](#)³ is a Centre of Research Excellence funded by the Tertiary Education Commission and hosted by the University of Auckland. It was awarded the Te Pūiaki Pūtaiao Matua a Te Pirimia Prime Minister’s Science Prize in 2020. The open-source model and policy simulator were partly funded by the [COVID-19 Innovation Acceleration Fund](#)⁴ and facilities and services from MBIE-supported [New Zealand eScience Infrastructure, NeSI](#)⁵. As former Director, Shaun would like to acknowledge the team from Te Pūnaha Matatini who gave their time to this project and to thank [Professor Juliet Gerard](#)⁶, [Professor Ian Town](#)⁷ and [Dr Siouxsie Wiles](#)⁸ for their “amazing contributions” to the response.

Science and innovation awards celebrate excellence

Awards to researchers, scholars and innovators recognise those who have excelled in their fields and advanced science and technology to meet today’s challenges.

Recent recipients include:

- Dr Ocean Mercier, who was awarded the 2019 Callaghan Medal and Professor Rangi Mātāmua who was awarded the 2020 Callaghan Medal for their work in engaging the public in science and mātauranga Māori
- Professor Mark Weatherall and Mark Holliday, who received the Liley Medal for asthma research
- Ranjna Patel, the 2021 New Zealand Innovator of the Year
- Moxion Ltd won the 2021 Hi-Tech Start-up Company of the Year award.

For more information see: [Fieldays Innovation Awards](#)⁹, [Health Research Council Awards](#)¹⁰, [New Zealand Innovator of the Year](#)¹¹, [NZ Hi-Tech Awards](#)¹², [Prime Minister’s Science Prizes](#)¹³ and [Royal Society Te Apārangi medals and awards](#)¹⁴.

CHAPTER 6

Hanga pāpātanga

Creating impact



Kei roto i tēnei wāhanga

In this chapter

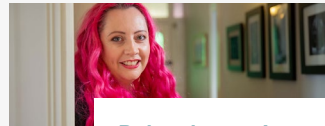
6.1 Te whakaarumoni i te R&D

Commercialisation of R&D

76

He mātai take

Case study



Relentless science
communication in
the time of COVID

→ 80

Kupu whakataki Introduction

Governments worldwide increasingly require that public investments in research demonstrate tangible impacts that benefit the economy, society or environment beyond a contribution to knowledge or skills in research organisations. To do this, publicly funded researchers in New Zealand are asked to maintain a 'line-of-sight to impact'. This is intended to help them understand their part in the bigger picture – how their activities have or could contribute to improving the wellbeing of New Zealanders.

Impacts are unpredictable and some may only become apparent in retrospect. Many factors beyond the research system affect impacts, which makes them challenging to measure. For this reason, data-driven impact analysis often stops at outputs (research products such as papers and presentations that can be measured easily). Case studies, however, can provide insight into the successful uptake of research and scientific expertise in the absence of comprehensive data. The Ministry of Business, Innovation and Employment is working to extend measurement to actual impacts by linking datasets and qualitative approaches.

Impact to the economy results from research being commercialised and new products and services entering the market. Non-commercialised research can also have

an impact. The modelling of COVID-19 in New Zealand that informed government decisions around lockdowns for example, is likely to have had a significant social impact.

Patents are the intellectual property right used to protect inventions. For a patent application to be granted, an invention must be new, useful and not obvious. Patents are often used as a metric for innovation that has commercial potential. There are also other approaches to commercialisation that do not involve patents.

This chapter uses patent data granted to resident inventors and foreign-oriented patent family applications as a basic gauge of how New Zealand is performing relative to other countries.

Ngā miramira wāhanga Chapter highlights

Patent information can be used as an indication of commercial innovation.

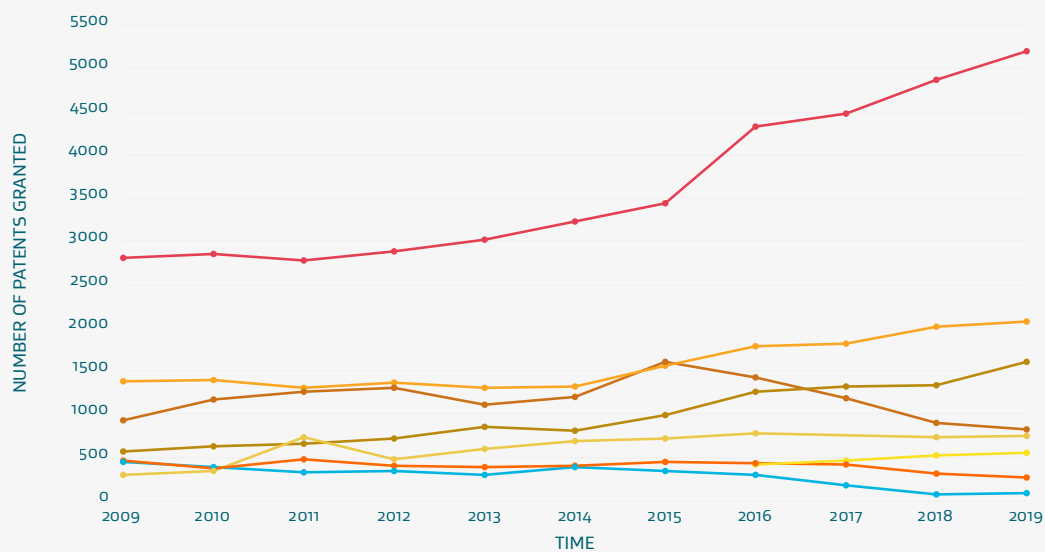
New Zealand has a low number of patents granted to resident inventors and a low number of foreign-oriented patent family applications relative to other small advanced economies and Australia.

Data to measure the impact of research, science and innovation activities on organisations and people is limited.

6.1 Te whakaarumoni i te R&D Commercialisation of R&D

FIGURE 41
Patents granted to resident inventors

The number of patents granted in New Zealand to residents of this country has declined by 79 per cent since 2009 and totalled 94 in 2019. This is low compared with other small advanced economies and Australia.



Data source:

World Intellectual Property Organisation patent statistics See page 101

Total patents granted to resident applicants. The grant of a patent allows the applicant or assignee to make use of and exploit an invention for a limited period of time. Note that patent applications may take several years to be granted.

Country/region

- Switzerland
- Finland
- Denmark
- Australia
- Israel
- Ireland
- Singapore
- New Zealand

Whakakitenga: using virtual reality technology to support Māori storytelling

Whakakitenga is the first virtual reality film made in te reo Māori. It explores the historical world of Te Rangihaeata, a Ngāti Toa Rangatira warrior, poet, gardener and carver. It was written and directed by Wiremu Grace and co-directed by Miriam Ross and Paul Wolfram.

The project was a collaboration between Ngāti Toa Rangatira and Victoria University of Wellington Te Herenga Waka. It began with the aim of using new audiovisual technologies to explore the ongoing impacts of colonisation. *Whakakitenga* was designed and made with the intention of building capacity for Māori to engage with the storytelling power of virtual reality.

[Read more¹](#)

COVID-19 vaccine strategy

Ensuring access to a safe and effective vaccine as early as possible

This strategy aimed to ensure New Zealand had detailed knowledge of international research efforts and could assess promising vaccine candidates as they emerged. New Zealand also advocated for a COVID-19 vaccine being distributed equitably, with a particular focus on our Pacific Island partners.

The government allocated funding to support:

- vaccine research in New Zealand
- potential manufacturing capability in this country
- international research collaborations including those managed by the Coalition for Epidemic Preparedness Innovations
- the vaccine alliance Gavi, which distributes vaccines to developing countries.

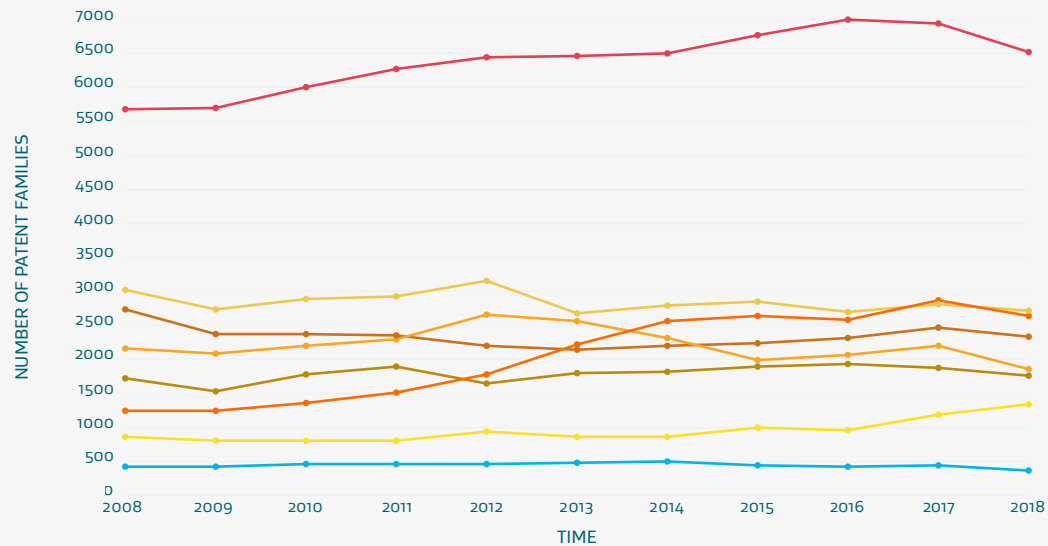
[Read more²](#)

FIGURE 42

Foreign-oriented patent families

Patent applications by New Zealand inventors in foreign jurisdictions peaked in 2014 with 504 applications, and has since declined. Patenting activity by New Zealand inventors is low compared to other small advanced economies.

Patent families are a set of related patent applications filed in one or more countries to protect the same or a similar invention. A foreign-oriented patent family refers to a patent family having at least one filing office that is different from the office of the applicant's origin. Inventors tend to apply for patents in foreign jurisdictions when they see potential financial returns or other advantages from protecting their invention in these markets.



Data source:

World Intellectual Property Organisation patent statistics See page 101

Patent families are a collection of patent applications covering the same intellectual property or the same or similar technical content that are registered in multiple jurisdictions. Note that patent applications may take several years to be granted.

Country/region

- Switzerland
- Israel
- Singapore
- Australia
- Finland
- Denmark
- Ireland
- New Zealand

Boosting Māori data capability for a better future

A joint initiative between Callaghan Innovation and Figure.NZ created an online platform aimed at boosting data capability for the Māori economy.

Pātaka Raraunga is a website that brings together data, tools and reports on te ao Māori. Its aim is to make data for and about Māori accessible in order to inform decision-making in Māori businesses. The site also provides digital resources to teach data literacy and hosts Māori data webinars.

Data on the platform is constantly being updated and new datasets added. Users can also request the addition of data that may not be present. Since the site was launched in October 2020, more than 10,000 people who are Māori or work to support Māori have engaged with its data.

Pātaka Raraunga has helped individual organisations and businesses achieve success and researchers have reported time savings from easier access to reputable data. It has also encouraged leaders of Pasifika and disabilities communities to design similar sites to meet their needs.

[Read more³](#)



CASE STUDY

RELENTLESS SCIENCE COMMUNICATION IN THE TIME OF COVID

*Dr Siouxsie Wiles
Credit Arvid Eriksson*

Siouxsie Wiles, Principal Investigator, Te Pūnaha Matatini

Throughout the COVID-19 pandemic, Siouxsie Wiles guided New Zealanders' actions with sensible and timely information about the virus and how to beat it. She stepped up willingly, having been training unwittingly for the role for the last decade.

"I've spent more than 10 years working with journalists, artists and illustrators to learn how to be a better communicator. I didn't just drop in fully formed."

Siouxsie is an associate professor at the University of Auckland and leads the Bioluminescent Superbugs Lab. She always hoped her work would make a difference.

"I assumed it would be through my research by helping develop a new antibiotic. But through the pandemic, I've learned that I can have a huge impact globally by doing good science communication."

Together with illustrator Toby Morris, Siouxsie created many memorable gifs that were shared around the world and translated into lots of different languages.

"They've been used by refugee communities, in doctors surgeries, to educate people working in the youth justice system in the USA - all sorts of things. It's been the most productive and impactful collaboration I've ever had, which after 20 years as a scientist is quite something."

While communicating science is fundamental for Siouxsie, she believes it should be valued and funded as part of every research grant.

"That would create a generation of academics who are incentivised to work alongside communities, who value communication and do what their country needs them to do rather than being focussed on only writing academic papers."

Siouxsie's high profile in the media has challenged public perceptions of scientists.

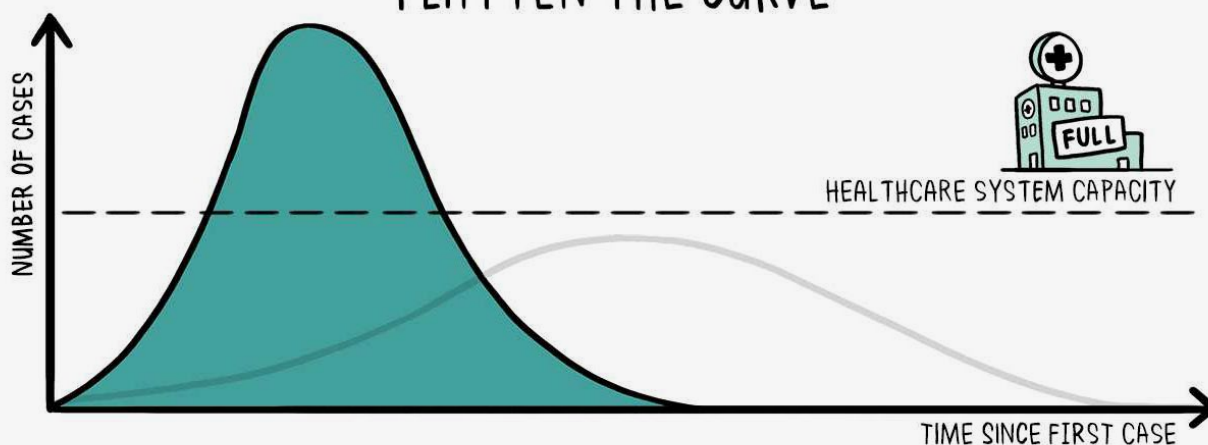
"One of the reasons for keeping my hair pink is because kids kept saying they didn't think scientists could look like me. Others said I'd shown it was OK to be themselves and still be a scientist. That's made me determined to make my lab an inclusive environment where people from diverse backgrounds feel welcome."

Despite a career-long research interest in microbiology, a need for more knowledge about viruses is not the standout lesson Siouxsie will take from the pandemic.

"What it's taught me most is that people are far more important. We have one organism going around the world but the pandemic is playing out really differently in different countries. That's simply because of people's actions, cultures and governments. What we've done here is amazing!"

Siouxsie was named 2021 New Zealander of the Year and was the supreme winner and the winner of the innovation, science and health category at the 2020 Stuff-Westpac Women of Influence Awards. She also won the Prime Minister's Science Media Communication Prize in 2013. Siouxsie would like to acknowledge her family and the members of her lab, all her colleagues at Te Pūnaha Matatini, Toby Manhire (The Spinoff editor) and Toby Morris (illustrator). The COVID-19 gifs caught the attention of the World Health Organization, which contracted The Spinoff to provide illustrations and videos.

FLATTEN THE CURVE



@SIOUXSIEW @XTOTL @THESPINOFFTV

'ADAPTED FROM @DREWAHARRIS, THOMAS SPLETTSTÖBER (@SPLETTE) AND THE CDC' CC-BY-SA

CHAPTER 7

Tētahi hungamahi kanorau, whai pūkenga A diverse and skilled workforce



Kei roto i tēnei wāhanga In this chapter

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Attracting and retaining skilled workers from overseas | 96 |

He mātai take Case study



Listening to the voice of the taniwha 86

Top image left to right: Leilani Rickard (Ngāti Rangiwewehi, Tuhourangi, Ngāti Rangitihī, Ngāti Whakaue), Dr Nancy Garrity (Ngāti Makirangi, Ngāti Pāoa, Ngāti Hine), Anastasia Rickard (Ngāti Whakaue, Ngāti Porou, Te Arawa, Tainui). This team is working on a Science for Technological Innovation project called Consolidating cordyline for green composites. Credit Stephen Parker.

Kupu whakataki Introduction

People in the research, science and innovation (RSI) system have skills, knowledge, ideas and connections, which they use to create, apply and communicate knowledge. Diversity is vital for research and innovation, as it provides a breadth of different ideas, backgrounds, knowledge and experiences. This creates greater opportunities for new thinking and new directions.

Nurturing and growing emerging researchers and offering them stable career pathways is important for the RSI system in New Zealand. Attracting people with unique skills and experience from overseas is also vital, because New Zealand's workforce currently has a shortage in some areas (ie engineers, scientists, ICT professionals, university lecturers and postdoctoral fellows). Increasing the R&D workforce is essential to achieve the government's goal of growing R&D to 2 per cent of GDP by 2027.

This chapter presents the changing demographics of the RSI workforce. Progress towards a diverse workforce, which is recognised as essential for excellence in all fields, is also reported. The workforce pipeline is also explored, including the number of young people entering the sector with relevant qualifications and skills.

Ngā miramira wāhanga Chapter highlights

In 2020, the R&D workforce comprised 1.5 per cent of the total New Zealand workforce.

The occupation make-up of the R&D workforce varies by sector, with business and government sectors having the most technical and support staff.

Ethnic and gender diversity is varied across the R&D workforce and fields of work or study.

Trends in the composition of science, technology, engineering and mathematics (STEM) students suggest that the science and research pipeline is increasingly reliant on **international students and immigration.**

7.1 Te rahi me te kāhua o te hungamahi RSI

Size and profile of the RSI workforce

FIGURE 43

Size of the R&D workforce by sector and occupation

The research and development workforce comprises technicians, support staff and researchers.

Researchers are defined as professionals who are engaged in the conception or creation of new knowledge. They conduct research and improve or develop concepts, theories, models, techniques, instrumentation, software or operational methods. They are typically involved in managing R&D projects. (See *OECD Industry Scoreboard*¹ page 104).

The make-up of the workforce varies by sector. Support and technical staff comprise approximately 43–46 per cent of personnel involved in R&D in the business and government sectors and 13 per cent in the higher education sector.

The R&D workforce increased by 47 per cent between 2010 and 2020. The business sector workforce had the greatest increase, with numbers more than doubling between 2010 and 2020. This compares to a 15 per cent increase in the higher education sector and a slight (0.6 per cent) increase in the government sector for the same period.

ORCID – a digital ID for researchers

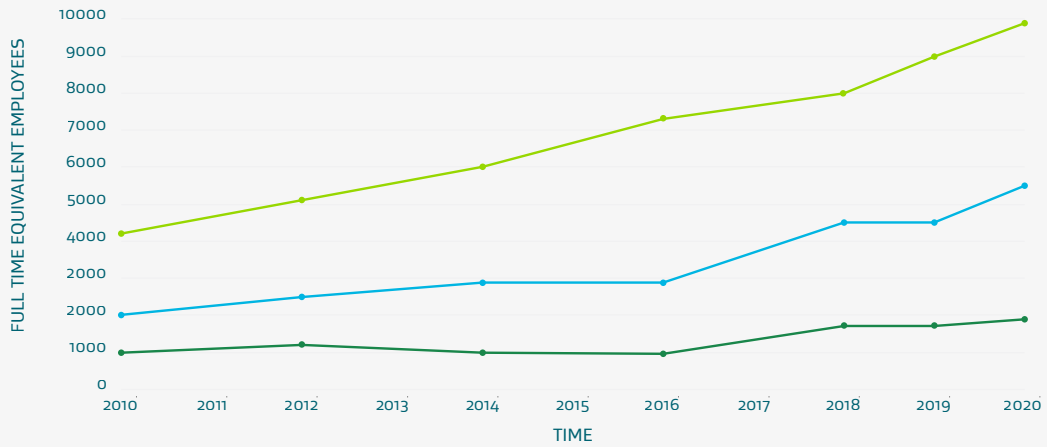
A unique ORCID number enables researchers in any field to distinguish themselves professionally, to ensure scientific outputs are credited unambiguously. The Royal Society Te Apārangi is the lead agency of a national consortium that manages membership for organisations (usually at no cost) and provides technical support through the NZ ORCID Hub.

More than 20,000 ORCID holders have now stated a New Zealand affiliation publicly in their biography. As at August 2020, 46 per cent of New Zealand-affiliated authors had published with an ORCID number, compared to 17 per cent in 2018.

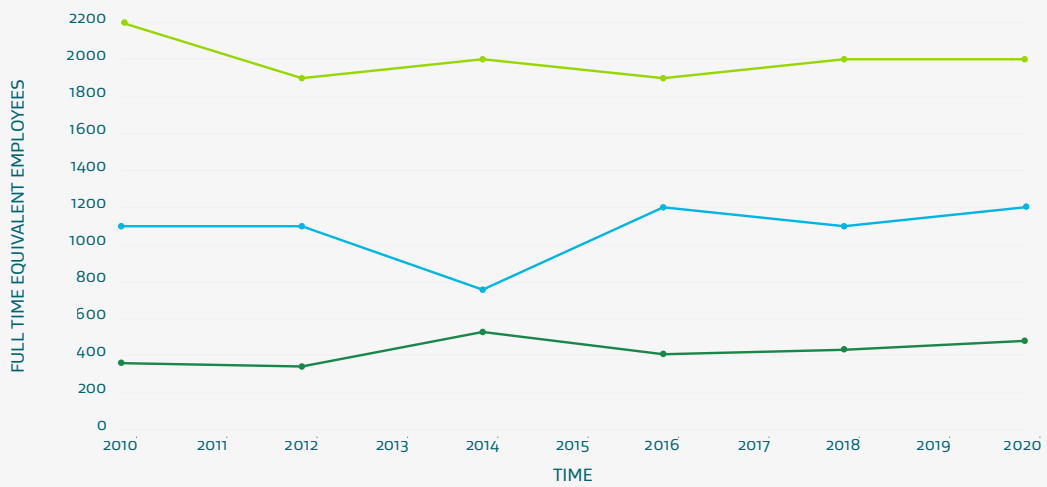
[Read more](#)³

1. www.oecd-ilibrary.org/science-and-technology/oecd-science-technology-and-industry-scoreboard-2017_9789264268821-en
 2. <https://www.stats.govt.nz/information-releases/research-and-development-survey-2019> 3. info.orcid.org/what-is-orcid/

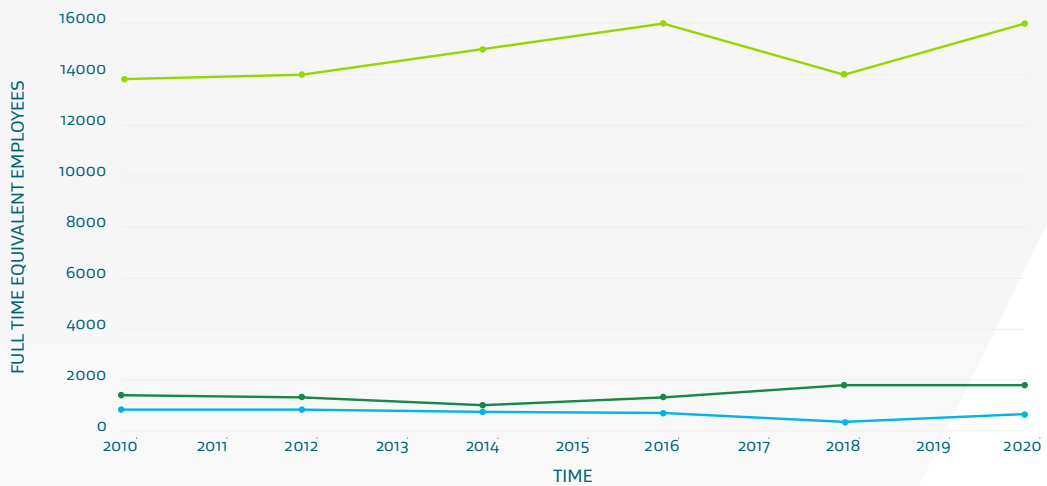
Business enterprise



Government



Higher education



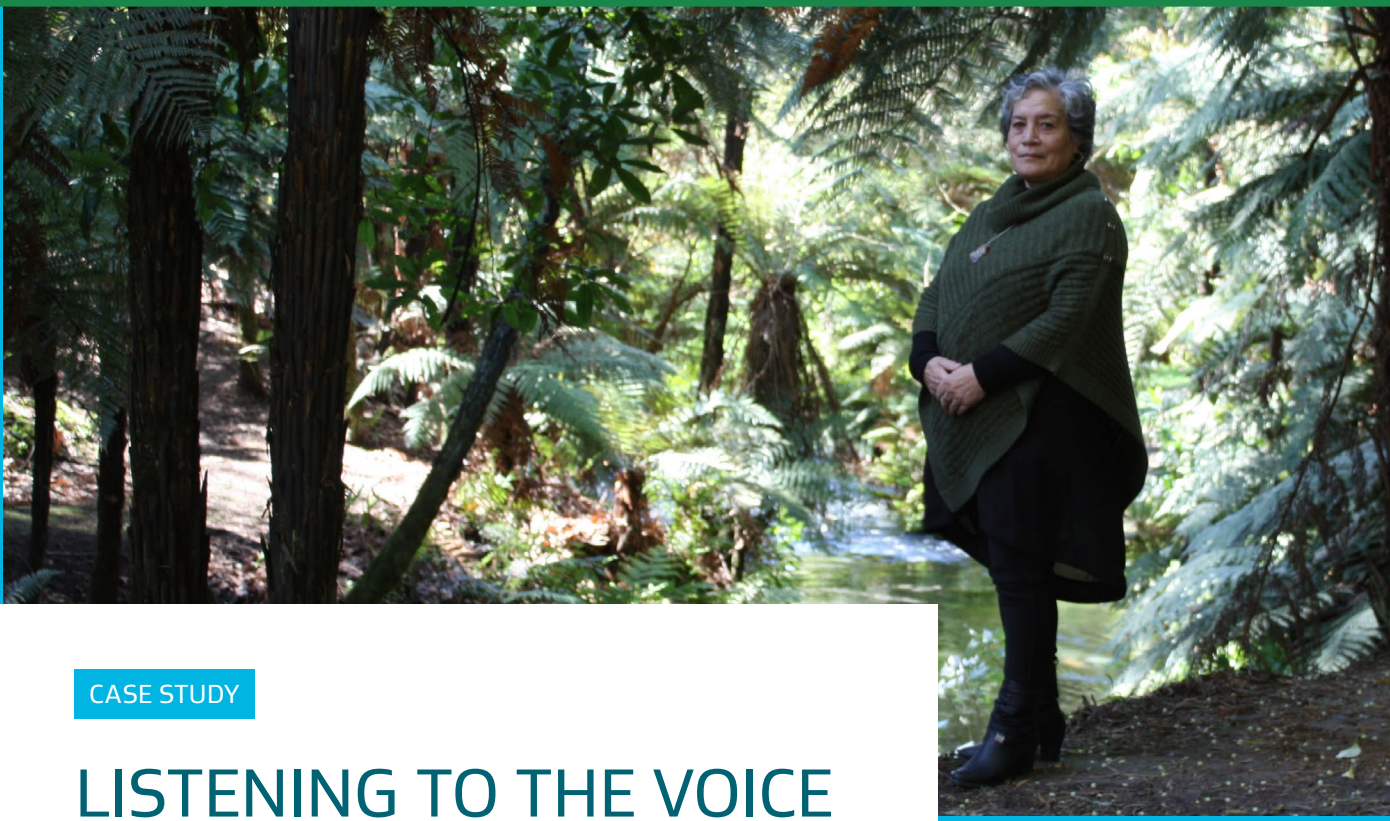
Data source:

Stats NZ research and development survey See page 101

Data for total R&D expenditure comes from the [research and development survey](#)². Spending by businesses, universities, Crown research institutes and government agencies is included. In 2019, the survey was conducted for the business sector only. The government and higher education sectors are surveyed every 2 years and are included in the 2020 survey. Business enterprise, government and higher education R&D workforce sectors are shown separately.

Occupation

- Researcher
- Support staff
- Technician



CASE STUDY

LISTENING TO THE VOICE OF THE TANIWHA

*Te Rangikaheke Bidois QSM,
Ngāti Rangiwewehi kaumātua.
Credit Paul White, GNS Science.*

Te Rangikaheke Bidois QSM, Ngāti Rangiwewehi

Mātauranga Māori and scientific knowledge were brought together to enable iwi to set a minimum water flow for the spring-fed Awahou Stream, Rotorua.

More than 200 springs, including Taniwha Springs, flow from several hectares of land north of Lake Rotorua. Their waters mingle to form a lively, gushing stream that is pure and snow-cold.

Like the local children today, Te Rangikaheke Bidois played in Awahou Stream as a child. “There’s a photo of me as a 3-year-old sitting on a patch of grass in the middle of the stream, with water bubbling past. Everything was in its natural state then.”

“Nā mātou o te wai, nā mātou anō te kōrero – we are people of the water and this is our kōrero (story). I’ve drunk this water my whole life. Our people travel all over the world but the sense of belonging to this place never leaves us. We have this unbreakable connection to the whenua (land) and the wai (water). Because we have the knowledge of the wai, we have the say.”

In 1966, 1 hectare of land in Taniwha Springs was acquired by the then Rotorua Borough Council to supply water to the nearby township of Ngongotahā. Within this area was a major spring called Te Waro Uri. The acquisition triggered a significant grievance between iwi and the council. Assisted by a Treaty of Waitangi claim, iwi kaitiakitanga (guardianship) over the springs was eventually restored in 2014 and the current Rotorua Lakes Council returned the land in 2018. Today the Ngongotahā Municipal Water Supply is co-managed by Ngāti Rangiwewehi and Rotorua Lakes Council through the Pekehaua Puna Reserve Trust Joint Resource Consent and Management Agreement.

“We received an apology from the Crown, but what was done has caused deep mamae (hurt) to our old people. Although every generation inherits that mamae, we’ve never lost the connection to our water.”

Ngāti Rangiwewehi are also proud of their pragmatism and resilience and have found ways forward. “As an iwi we value our ability to manaaki (care for) others. We see the bigger picture of how this resource that’s our taonga (treasure), has been able to sustain the wider community.”

Since 2014, the resource consent to take water from Taniwha Springs has been of prime interest to Ngāti Rangiwewehi. Iwi were concerned that a proposed increase in volume would negatively affect the mauri (life force) of the stream, especially if housing in the area increased.

Enter Paul White, a GNS Science geohydrologist based in Taupō. Paul was invited by Ngāti Rangiwewehi to bring science alongside iwi mātauranga (knowledge). He provided advice that allowed iwi to determine how much water could be taken without compromising the mauri of the stream. This level – the ‘kaitiaki flow’ – was decided through three hui (meetings) in 2017 and 2018.

Several questions informed discussions at the hui including: Why do we feel it is important for us to protect and care for our wai? How should we acknowledge the pūrākau (stories) of our taniwha and our waterways? What regular scientific information do tangata whenua need to know about their waterways? What role do iwi have in ensuring water allocation doesn’t impact negatively on the wai?

Paul and his colleagues researched the extent of the catchment and modelled how water enters the springs. They advised on

what could influence the water flow and quality, and created images of how different consent conditions would change the appearance of the stream.

Iwi decided that water use would be allowed when the stream flow was greater than the kaitiaki flow (defined as 90 per cent of the natural flow). Kaitiaki flow is now part of the Taniwha Springs water supply consent application. Also, a new permanent flow measurement site will be installed to provide iwi with monitoring data.

“We’re pleased to have had this opportunity in partnership with our local authority, to show how mātauranga Māori can ensure this resource is used sustainably. We want to encourage other iwi and Te Tiriti (Treaty) partners to look at how they can use their unique mātauranga and modelling in their own contexts. Together, we can all ensure the wai is there to sustain our people and provide for future generations.”

Te Rangikeheke Bidois would like to warmly thank all those involved in the project, especially Paul White, GNS Science, Kerri Anne Hancock, Lee-Anne Bidois, Gina Mohi, and Ngāti Rangiwewehi kaumātua and iwi members. Funding was provided by Ngāti Rangiwewehi through Te Tāhuhu o Tawakeheimoa Trust, Pekehaua Puna Reserve Trust with support from Te Kaikaitahuna Management Co Ltd, Rangiwewehi Charitable Trust and Te Pūnaha Hihiko – Vision Mātauranga Capability Fund.

White, P. A., Bidois, L.-A., Mohi, G. & McGrath, W. (2020). Kaitiaki flow and management regime in the spring-fed Awahou Stream, Lake Rotorua. *Journal of Hydrology (NZ)* 59(1):63–78.



Paul White (centre) teaching children from Te Kōhanga Reo o Tarimano and Te Kura Kaupapa Māori o Te Koutu about the hydrology of the Awahou Stream area. Credit: Heather Martindale.

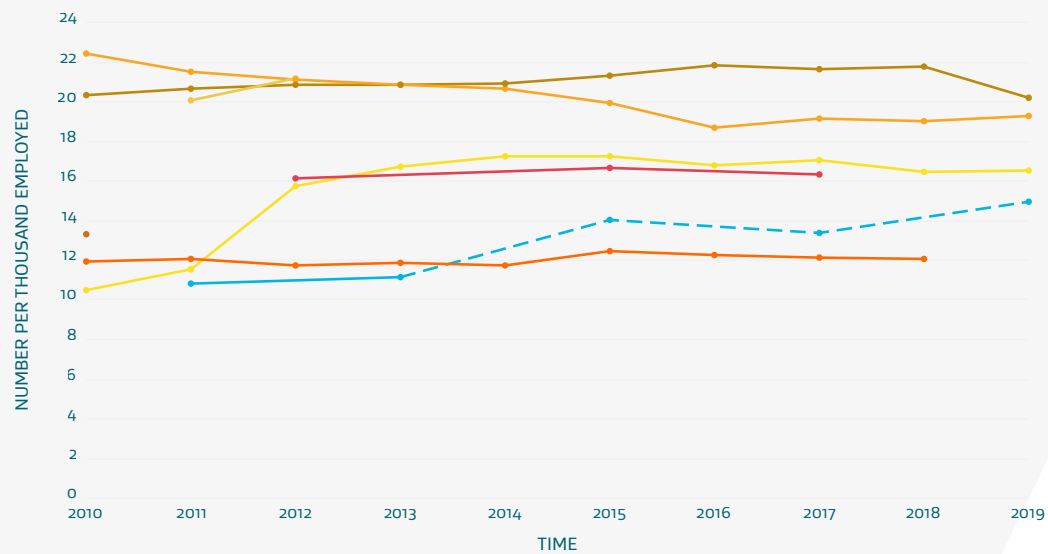
FIGURE 44

R&D workforce as a proportion of the total workforce compared with other small advanced economies

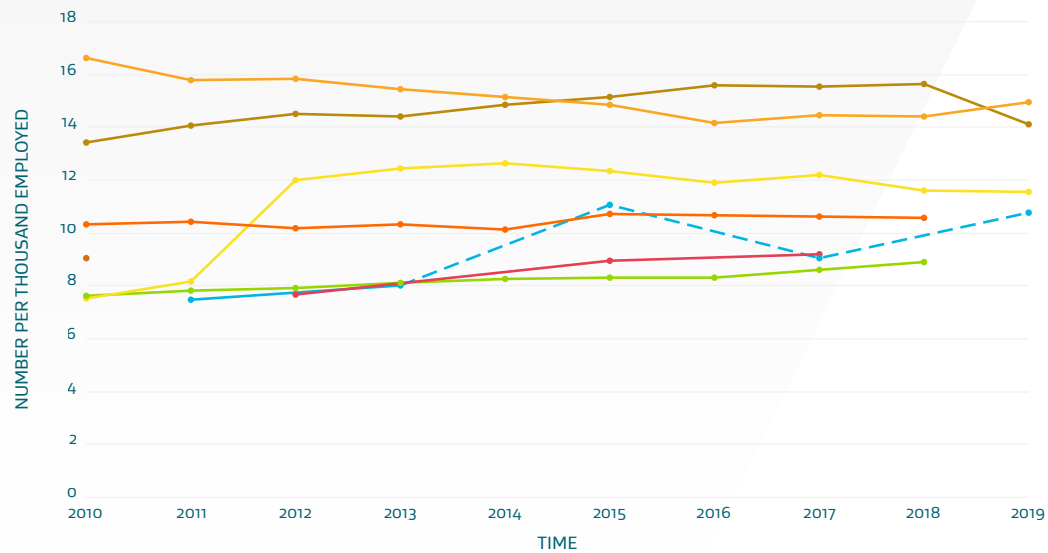
The R&D workforce (including researchers, support staff and technicians) has increased as a proportion of New Zealand's total employed workforce since 2011. The R&D workforce made up 15.0 per 1000 New Zealanders employed in 2019, which was lower than other small advanced economies except Singapore.

In 2019, the researcher workforce (total researchers excluding support staff and technicians) comprised 10.8 per 1000 New Zealanders employed. This figure is lower than Denmark, Finland and Ireland, but higher than the OECD- Totals and Switzerland.

Total R&D personnel per thousand total employment



Total researchers per thousand total employment



Data source:

OECD main science and technology indicators See page 101

Stats NZ research and development survey See page 101

The OECD offsets New Zealand R&D survey data by 1 year for comparative purposes (ie 2018 Stats NZ R&D data is shown as 2017 OECD data). Data for 2015 and 2017 is recalculated based on revised 2020 Stats NZ R&D survey data and data for 2019 is approximated based on 2020 Stats NZ R&D survey data. The dashed lines lead through approximated values.

Country/region

- New Zealand
- OECD - Total
- Australia
- Denmark
- Finland
- Ireland
- Israel
- Singapore
- Switzerland

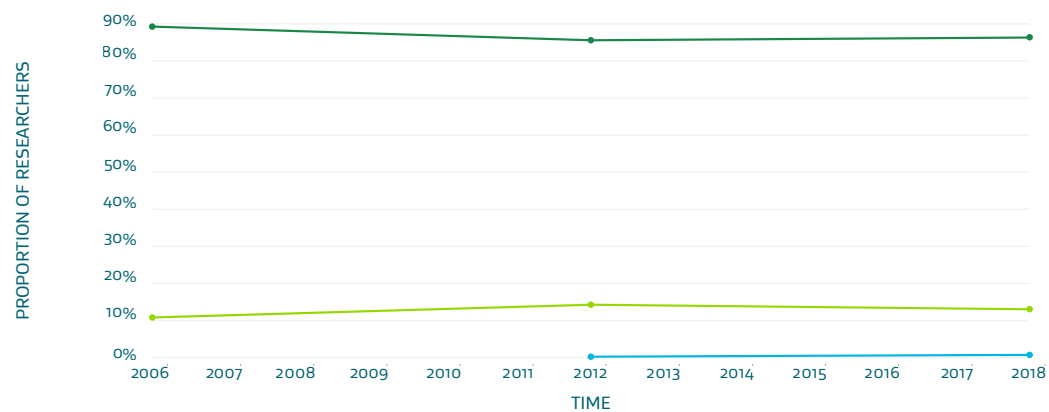
7.2 Kanorautanga i roto i te hungamahi RSI Diversity in the RSI workforce

FIGURE 45
Tertiary sector researchers by gender and field

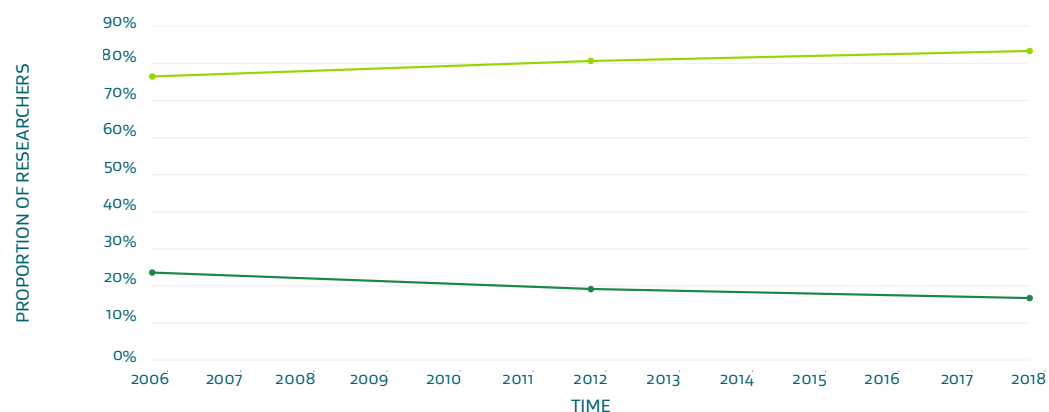
There is limited data to monitor the composition of the researcher workforce, but data from Performance-Based Research Fund (PBRF) evaluations give some indication for the tertiary sector.

In 2018, female researchers were under-represented in disciplines related to STEM (science, technology, engineering and mathematics). They made up less than 25 per cent of researchers in fields such as engineering and technology, physics and computer science. In the same year, male researchers made up less than 30 per cent of researchers in nursing, Pacific research and education.

Engineering and Technology



Nursing



Data source:
Tertiary Education Commission PBRF quality evaluation See page 101

Data was sourced from Performance-Based Research Fund's (PBRF) quality evaluations on 17/01/2019. Researcher demographic data is based on PBRF-eligible staff whose evidence portfolio received a funded quality category. These results are weighted on a full-time equivalent (FTE) basis. Categories used for fields of research are based on PBRF quality evaluation subject areas and do not match ANZSRC standard reporting categories.

Gender

- Female
- Male
- Unknown

FIGURE 46

Tertiary sector researchers by ethnicity and field

The ethnic makeup of the researcher workforce is substantially different to the total population. Ethnic diversity also varied across fields of research.

The Māori population of New Zealand is 16.5 per cent, but in 35 of 43 fields of research, less than 5 per cent of researchers are Māori. Computer science, information technology, and information science fields have the lowest proportion of Māori researchers. In contrast, Māori knowledge and development, and visual arts and crafts have the highest proportions of Māori researchers.

Pacific Peoples comprise 8.1 per cent of the total New Zealand population, but make up less than 5 per cent of the total researchers in all fields except for Pacific research. Engineering technology and molecular, cellular and whole organism biology have the lowest proportion of Pacific researchers. Pacific research and public health have the highest proportions of Pacific researchers.

Since 2019, MBIE has implemented the equity, diversity and inclusion initiative to enable a science research system that attracts, promotes and reflects the diversity of New Zealanders.

A commitment to diversity in science

MBIE has published a Diversity in Science Statement to raise awareness of the importance of diversity in science and signal a commitment to do more. Part of this commitment is reporting on the diversity of award holders, assessment bodies and applicants to openly contestable funds such as the Endeavour and Catalyst Funds and Vision Mātauranga.

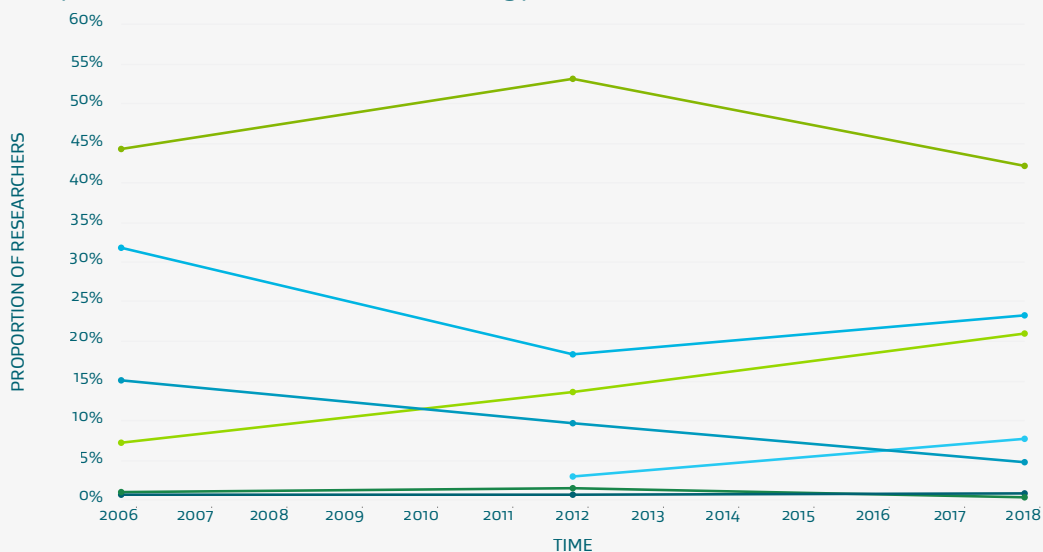
In 2021, 72.3 per cent of science leaders applying to openly contestable funds provided gender information for reporting purposes. Of these, 76.7 per cent identified as male, 22.5 per cent as female and 0.9 per cent as gender diverse. For the same group, 89.4 per cent provided ethnicity information and of these, 33.7 per cent identified as New Zealand European, 26.8 per cent as European, 3.7 per cent as Māori, 0.3 per cent Pasifika and the remainder stated another ethnicity.

For successful applications, 72.3 per cent of science leaders again provided gender information and of these, 75.0 per cent identified as male, 25.0 per cent as female and none as gender diverse. For the same group, 87.9 per cent provided ethnicity information and of these 39.3 per cent identified as New Zealand European, 32.1 per cent as European, 7.1 per cent as Māori and the remainder stated another ethnicity. No successful applicants identified as Pasifika.

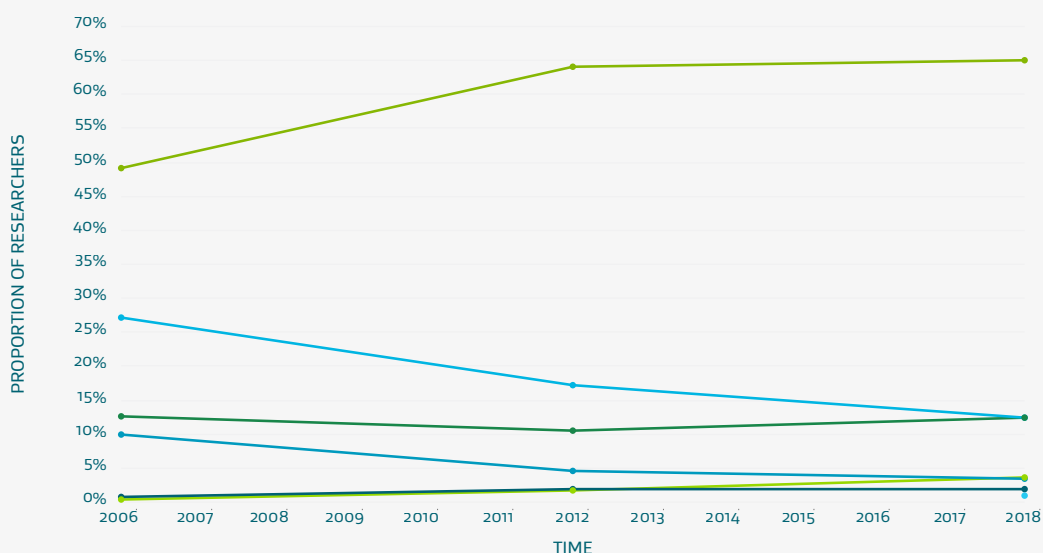
[Read more⁴](#)

4. www.mbie.govt.nz/science-and-technology/science-and-innovation/agencies-policies-and-budget-initiatives/diversity-in-science/

Computer Science, Information Technology, Information Sciences



Visual Arts and Crafts



Data source:

Tertiary Education Commission PBRF quality evaluation See page 101

Data was sourced from Performance-Based Research Fund's (PBRF) quality evaluations on 17/01/2019. Researcher demographic data is based on PBRF-eligible staff whose evidence portfolio received a funded quality category. These results are weighted on a full-time equivalent (FTE) basis.

Ethnicity

- Asian
- European
- Maori
- Middle Eastern/Latin America/African
- Not Stated
- Other Ethnicity
- Pacific peoples

7.3 Te whakatipu me te poipoi i ngā pūkenga STEM

Growing and nurturing STEM skills

92

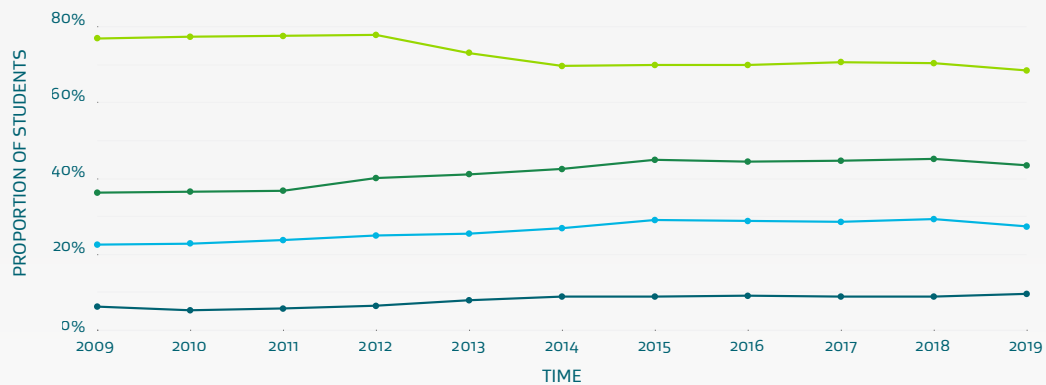
FIGURE 47

Proportion of students achieving NCEA in sciences, mathematics and statistics

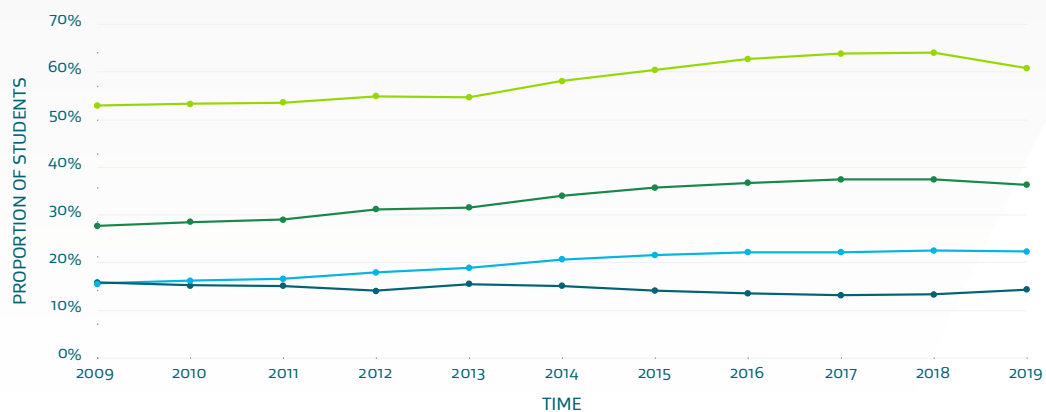
Growth in the R&D workforce depends on increasing students' mathematics and science skills at all levels. In early education, these are foundational skills for further technical and academic learning.

The trend shows that while relatively high numbers of students undertake STEM subjects in NCEA Level 1, this decreases significantly by NCEA Level 3. This reflects a decision by students not to pursue STEM subjects, which has implications for the RSI pipeline.

Mathematics and Statistics



Sciences



Data source:

Ministry of Education data request See page 100

Attainment is defined as attaining 14 or more credits where the result in standards is A, M, or E. A leaver is counted as non participant if they have not attempted any attainment in the learning area. Results from schools with more than 10 per cent of student attainment being assessed using International Baccalaureate, Cambridge International Qualifications or Accelerated Christian Education are not included in national figures.

NCEA levels

- Level 1 or above
- Level 2 or above
- Level 3 or above
- Non-Participant

FIGURE 48

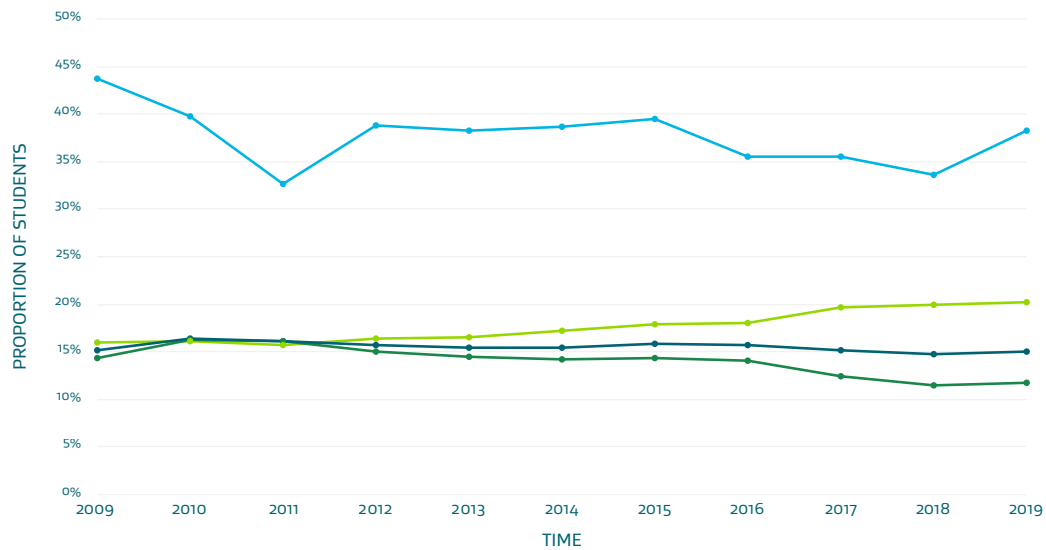
Proportion of graduates attaining degrees in STEM subjects

The proportion of bachelor and postgraduate students gaining qualifications in STEM subjects increased for domestic and international students from 2009 to 2019. International students were more likely than domestic students to complete undergraduate and postgraduate degrees in STEM subjects.

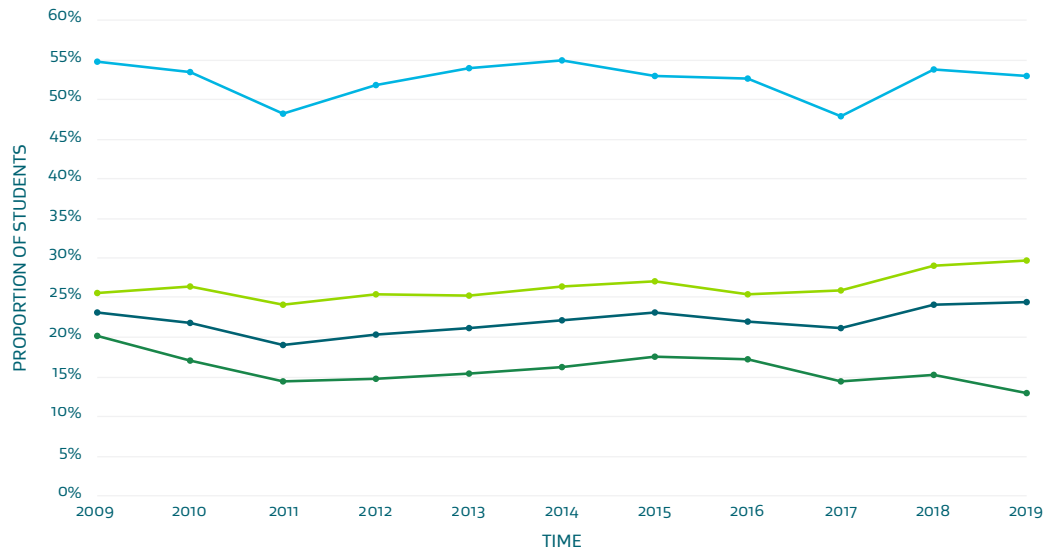
Since 2009, there has been no sustained upward trend in the number of domestic STEM doctorates. However, there has been an increase in international students awarded STEM doctorates, and this has contributed to the overall growth in doctorate completions.

These trends suggest the science and research pipeline is increasingly reliant on international students and immigrants joining the RSI workforce.

Domestic



International



Data source:

Ministry of Education data request See page 100

The data relates to students completing PhDs and other doctorates, but excludes higher doctorates. Students who complete a qualification that can be assigned to more than one field have been counted in each field, so the sum of the various fields may not add to the total. Data for 2019 is provisional. Counts are rounded to the nearest five to protect the privacy of individuals, so the sum of individual counts may not add to the total.

Graduate type

- Bachelors and postgraduate (excluding doctorates)
- Certificates and diplomas (Levels 1 to 7)
- Doctorates
- Total

7.4 Te whakarite i te puna rato kanorau o ngā kaimahi

Ensuring a diverse pipeline of workers

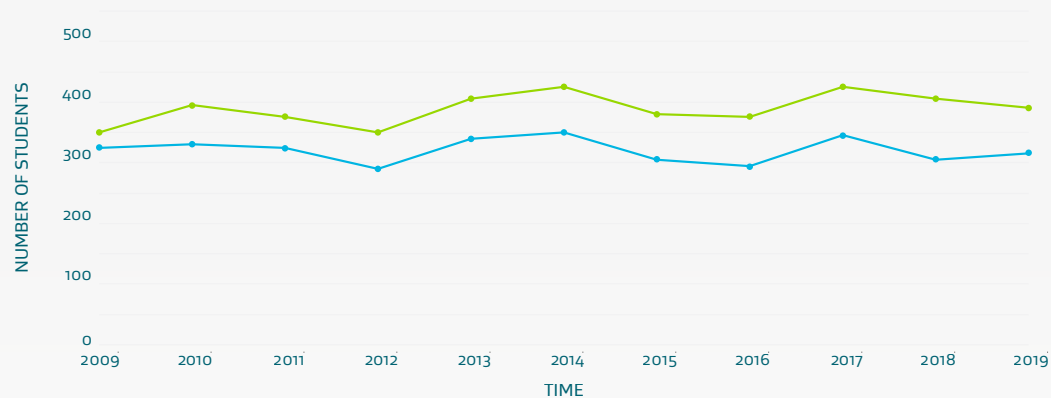
FIGURE 49

Doctorates completed by student gender and international status

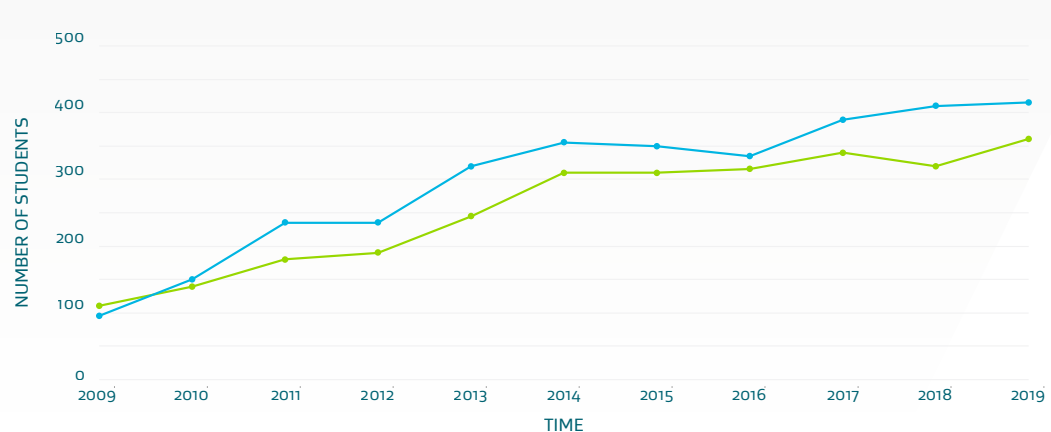
A large proportion of researchers have a doctorate degree. For New Zealanders, more than half of domestic doctoral graduates are female (55% in 2019). More international doctoral graduates are male (54% in 2019).

Domestic students are more likely to work in New Zealand after completing their degrees than international students. Trends in degree completions for this group are particularly important for the future diversity of the workforce.

Domestic



International



Data source:

Ministry of Education data request See page 100

The data relates to students completing PhDs and other doctorates but excludes higher doctorates. Students who complete a qualification that can be assigned to more than one field have been counted in each field, so the sum of the various fields may not add to the total. Data for 2019 is provisional. Counts are rounded to the nearest five to protect the privacy of individuals, so the sum of individual counts may not add to the total.

Gender

— Male
— Female

FIGURE 50

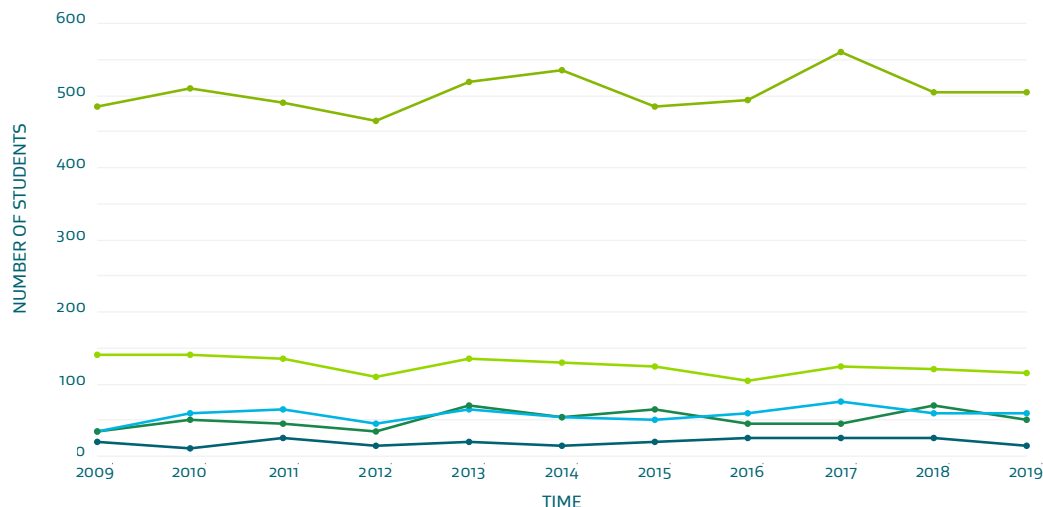
Doctorates completed by student ethnicity and international status

The proportion of Māori, Pacific Peoples and Asian students is low among domestic PhD graduates. This has implications for the diversity of the RSI workforce in the future.

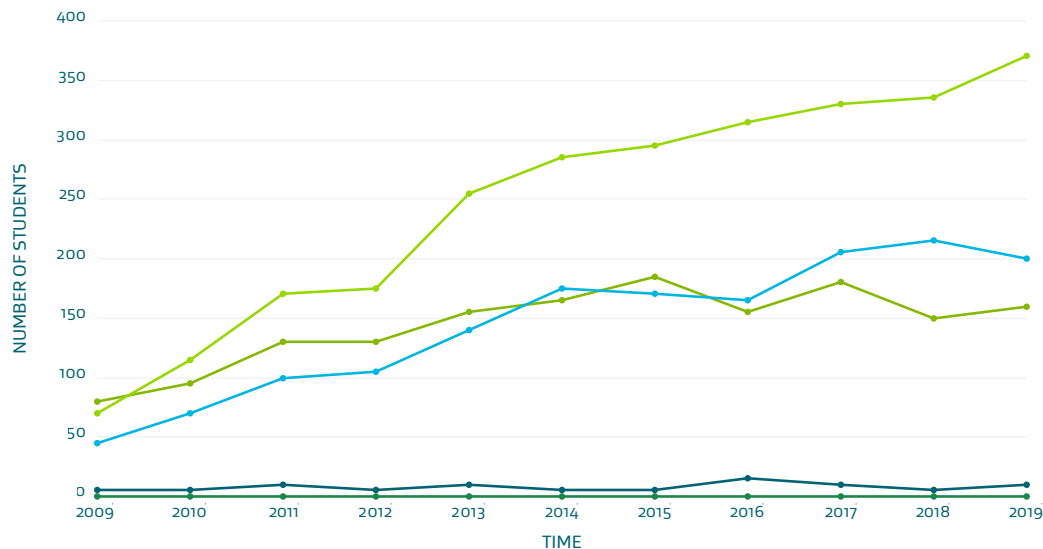
Māori and Pacific Peoples are also under-represented in the total number of PhD graduates compared to the ethnic mix of the New Zealand population. Between 2009 and 2019, Māori comprised almost 7 per cent of domestic doctoral graduates and Pacific Peoples about 3 per cent.

There were minimal increases in the number of doctoral completions by Māori and Pacific Peoples in the past decade. Also, the number of domestic Asian students has not reflected the five-fold increase in the number of international Asian students, which is a growing market for education.

Domestic



International



Data source:
Ministry of Education data request See page 100

Data relates to students completing PhDs and other doctorates but excludes higher doctorates. Students who complete a qualification that can be assigned to more than one field have been counted in each field, so the sum of the various fields may not add to the total. Data for 2019 is provisional. Counts are rounded to the nearest five to protect the privacy of individuals, so the sum of individual counts may not add to the total.

- Ethnicity**
- Asian
 - European
 - Maori
 - Other
 - Pacific peoples

FIGURE 51

Doctorates completed by student international status and field of study

In general, domestic students are under-represented in STEM subjects, which are important for the RSI workforce. This under-representation has increased in the past decade.

For both domestic and international students, more than 70 per cent of doctoral completions are in four research fields: engineering and related technologies, health, natural and physical sciences, and society and culture. The proportion of domestic students in these fields varies. For example, in 2019, 36 per cent of engineering and related technology PhD students were domestic students compared to 42 per cent in natural and physical sciences, 61 per cent in health, and 60 per cent in society and culture.

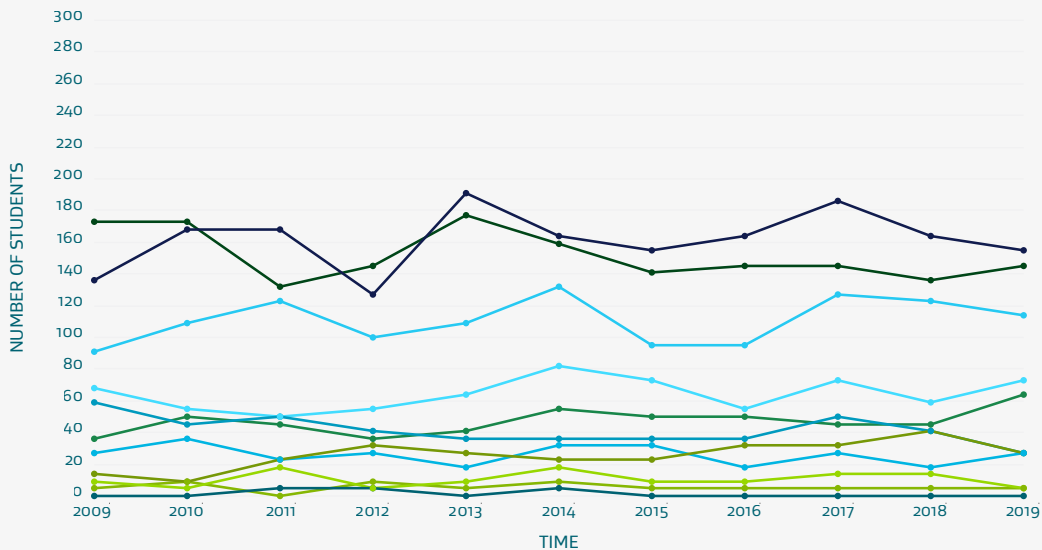
Māori and Pasifika scientists remain under-represented in Crown research institutes and universities

Research published in 2020 by a group of Māori and Pasifika scientists led by Dr Tara McAllister (Te Aitanga a Māhaki) provided empirical evidence that Māori and Pasifika scientists are severely under-represented in Crown research institutes and universities – and have been for at least 11 years. One university reported not employing a single Māori or Pasifika scientist for 11 years.

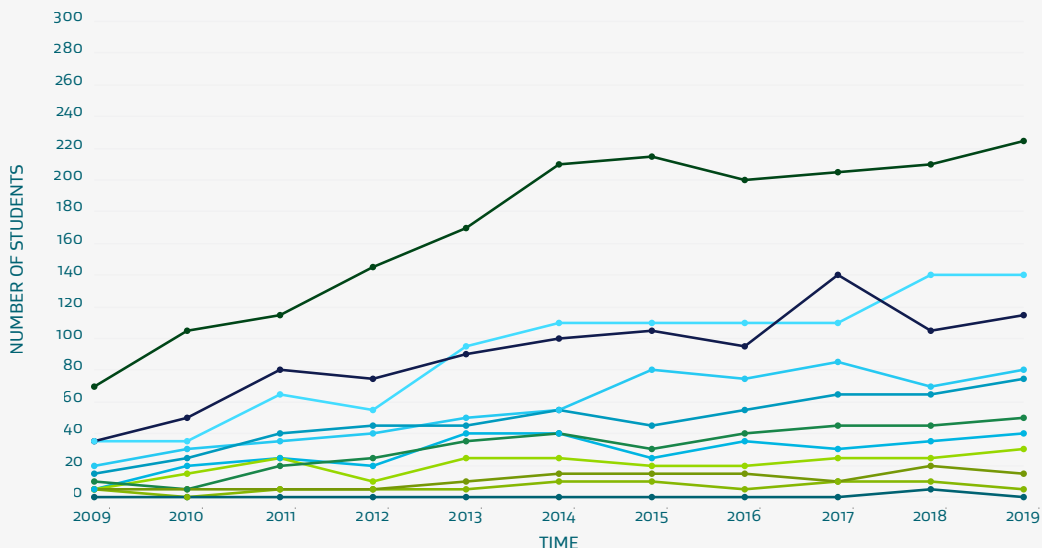
The research team argued that urgent structural changes are required to transform the lack of diversity in New Zealand's publicly funded scientific workforce. The team also highlighted that without Māori and Pacific voices, the science system will never reach its full potential.

This research was funded by MBIE and the Prime Minister's Chief Science Advisor. [Read more](#)⁵ or listen to an interview on [Breakfast TV](#)⁶.

Domestic



International



Data source:

Ministry of Education data request See page 100

Data relates to students completing PhDs and other doctorates but excludes higher doctorates. Students who complete a qualification that can be assigned to more than one field have been counted in each field, so the sum of the various fields may not add to the total. Data for 2019 is provisional. Counts are rounded to the nearest five to protect the privacy of individuals, so the sum of individual counts may not add to the total.

Field

- Agriculture, Environmental and Related Studies
- Architecture and Building
- Creative Arts
- Education
- Engineering and Related Technologies
- Health
- Information Technology
- Management and Commerce
- Mixed Field Programmes
- Natural and Physical Sciences
- Society and Culture

7.5 Te kukume me te pupuri kaimahi pūkenga mai i tāwāhi Attracting and retaining skilled workers from overseas

98

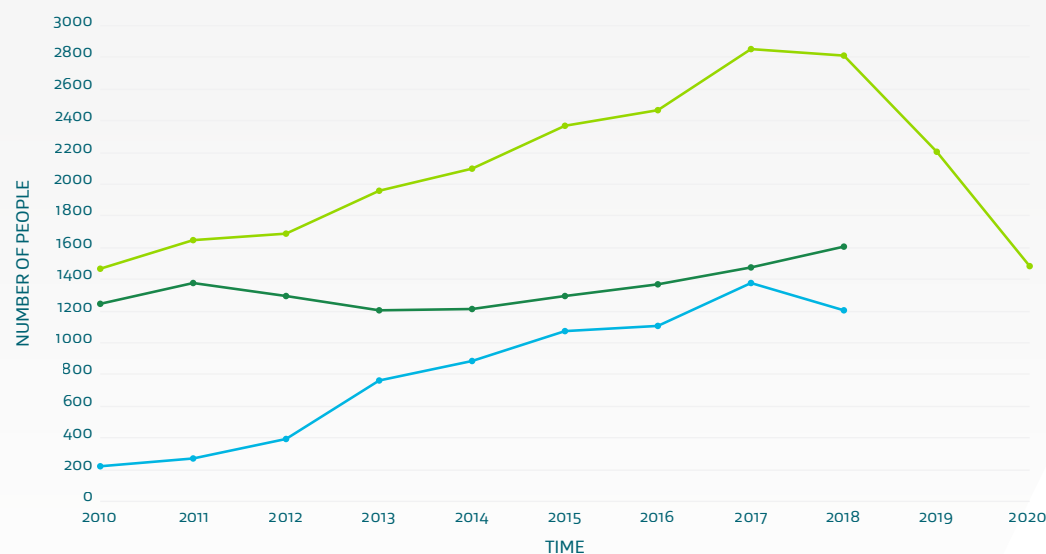
FIGURE 52

Migration and immigration of STEM professionals

Migrants bring valuable skills to the RSI system. The international movement of researchers and innovators also creates opportunities to build connections with overseas research institutions and businesses.

STEM professionals that can be identified in migration data include natural and physical science professionals, business and systems analysts and programmers, database and systems administrators, ICT security specialists, and ICT network and support professionals.

Between 2010 and 2018, there was a net increase in STEM professionals migrating to New Zealand. Changes to the immigration data sources in November 2018 and COVID-19 related border closures and travel disruptions, mean that a more recent trend cannot be presented here.



Data source:

Stats NZ [International travel and migration](#) See page 101

For detailed metadata about countries used in international travel and migration statistics, see [DataInfo+](#)⁷. Caution is advised when comparing permanent and long-term arrivals data before and since November 2018 because of changes in migration processing.

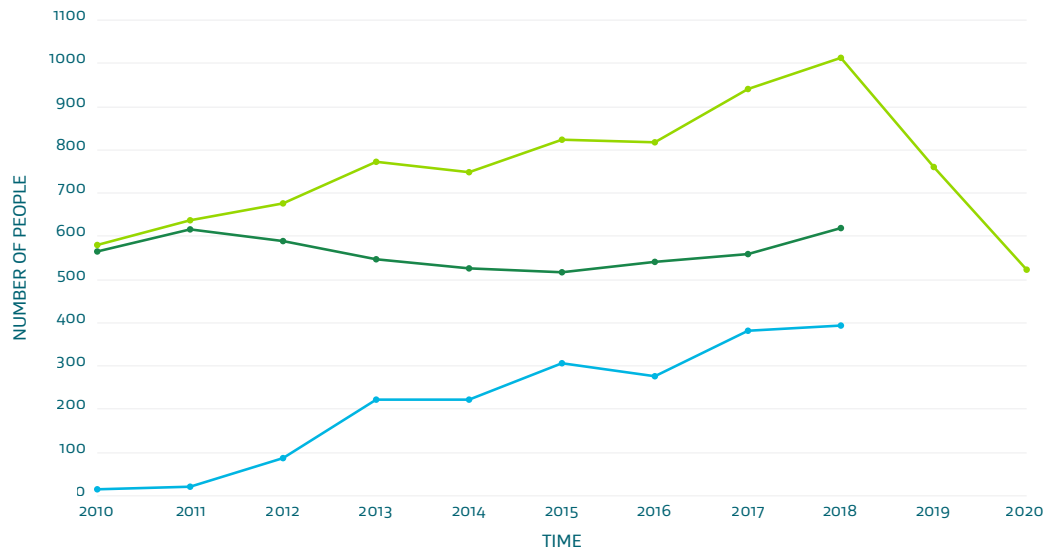
Migration

- Arrivals
- Departures
- Net

FIGURE 53
Migration and immigration of science professionals

Although similar to the arrival and departure migration trends of STEM professionals (see figure 52), the number of natural and physical science professionals is much lower. There was, however, a net increase in science professionals between 2010 and 2018.

Changes to the immigration data sources in November 2018 and COVID-19 related border closures and travel disruptions, mean that a more recent trend cannot be presented here.



Data source:
Stats NZ International travel and migration See page 101

For detailed metadata about countries used in international travel and migration statistics see [DataInfo+](#)⁷. Caution is advised when comparing permanent and long-term arrivals before and after November 2018 because of changes in migration processing.

Migration

- Arrivals
- Departures
- Net

Perspectives and progress from the Rauika Māngai

For the first time since the Vision Mātauranga policy was implemented in 2005, a collection of recommendations and guidance has been made available for New Zealand researchers and research institutions.

This seminal report, *A guide to Vision Mātauranga: Lessons from Māori voices in the New Zealand science sector*, collates the experience and perspectives of a hui of more than 100 Māori researchers from across the science sector. Importantly, the report provides practical guidance on building the critical ingredients for excellent Vision Mātauranga-relevant research, viewed through the lens of Treaty partnership.

The hui and the report that followed it were led by the Rauika Māngai, an assembly of Māori science leaders from the 11 National Science Challenges and Ngā Pae o te Māramatanga.

[Download the report](#)⁸

8. www.maramatanga.co.nz/sites/default/files/Rauika%20Ma%CC%84ngai_A%20Guide%20to%20Vision%20Ma%CC%84tauranga_FINAL.pdf

Ngā puna raraunga Data sources

100

Budget allocations in research and development by funding mechanism

The [New Zealand Treasury](#)¹ publishes the Government Estimates of Appropriations annually. MBIE has previously used these figures to estimate government budget allocations for research and development (GBARD) by funding mechanism.

researchscienceinnovation.nz/data/public-funding-by-mechanism-metadata

Dimensions bibliometrics data

[Dimensions](#)² is a linked research information dataset and tool, used to discover and access grants, publications, citations, clinical trials, patents and policy documents.

researchscienceinnovation.nz/data/dimensions-metadata

Ministry of Education data request

The [Ministry of Education](#)³ provided MBIE with custom data. This data covers STEM graduate statistics for domestic and international students, educational achievement statistics and other statistics relevant to New Zealand's education sector.

researchscienceinnovation.nz/data/moe-custom-data-metadata

New Zealand government budget allocation for research and development

Data on New Zealand GBARD is based on the New Zealand Treasury's annual Government Estimates of Appropriations.

researchscienceinnovation.nz/data/new-zealand-gbard-metadata

New Zealand Growth Capital Partners

[New Zealand Growth Capital Partners \(NZGCP\)](#)⁴ is a fund that was established by the government to help grow New Zealand's early-stage investment market. NZGCP collect data on start-up investment in New Zealand.

researchscienceinnovation.nz/data/nzgcp-metadata

New Zealand Private Capital Monitor

The [New Zealand Private Capital Association \(NZCA\)](#)⁵ and EY New Zealand run a survey of venture capital and private equity participants in the New Zealand market. Firms from New Zealand and Australia are included. The results of the survey are aggregated and published in the New Zealand Private Capital Monitor's annual release.

researchscienceinnovation.nz/data/nzca-activity-summary-metadata

OECD business innovation statistics and indicators

The OECD business innovation statistics and indicators are a biennial series of indicators of innovation activity in OECD member countries.

researchscienceinnovation.nz/data/oecd-innovation-metadata

OECD enterprise statistics

The OECD enterprise statistics are a series of global, comparable statistics on enterprise and entrepreneurship. This data is collected annually and provides in-depth data on venture capital investments in businesses by country and stage of business.

researchscienceinnovation.nz/data/oecd-es-metadata

OECD main science and technology indicators

The OECD main science and technology indicators (MSTI) database compiles an annual series of global, comparable statistics on science, research and innovation.

researchscienceinnovation.nz/data/oecd-msti-metadata

OECD research and development statistics

The OECD research and development statistics (RDS) represent a series of global, comparable statistics on expenditure, government budget allocations for R&D (GBARD) and personnel. The data is collected annually.

researchscienceinnovation.nz/data/oecd-rnd-metadata

Stats NZ business operations survey

This survey collects performance measures from New Zealand businesses to better understand the practices and behaviours they undertake that may affect their performance.

researchscienceinnovation.nz/data/lbd-datalab-metadata

Stats NZ business R&D data request

Stats NZ⁶ provided MBIE with custom data for business expenditure on research and development (BERD) across New Zealand, according to the business size and ranking.

researchscienceinnovation.nz/data/lbd-datalab-metadata

Stats NZ international travel and migration

International migration statistics provide the latest outcomes-based measure of migration, which includes estimates of migrants entering or leaving New Zealand.

researchscienceinnovation.nz/data/itm-data-metadata

Stats NZ research and development survey

The research and development survey measures the level of research and development activity, employment and expenditure across all sectors of the New Zealand economy.

researchscienceinnovation.nz/data/rad-metadata

TEC Performance-Based Research Fund Quality Evaluation

The Tertiary Education Commission (TEC)⁷ runs the Performance-Based Research Fund (PBRF) quality evaluation every 4 years. Data on the demographics of researchers working at tertiary education institutes is available as an output of the PBRF evaluation. This includes ethnicity and gender data.

researchscienceinnovation.nz/data/tec-metadata

World Intellectual Property Organization patent statistics

Patent data is obtained from the World Intellectual Property Organization (WIPO)⁸, which provides access to statistical data on intellectual property activity worldwide.

researchscienceinnovation.nz/data/wipo-metadata

Papakupu Glossary

Australian and New Zealand Standard Industry Classification (ANZSIC)

ANZSIC is a taxonomy that organises companies into industrial groupings based on similar production processes, similar products or similar behaviour in financial markets. The groupings are arranged into 19 broad industry divisions and 96 industry subdivisions. Two more detailed levels are called groups and classes. ANZSIC class codes are four-digit numbers. This report currently uses the 2006 edition of ANZSIC.

Australian and New Zealand Standard Research Classification (ANZSRC)

This is a set of three related classifications: type of activity (ToA), fields of research (FoR) and socioeconomic objective (SEO). These classifications have been developed for use in the measurement and analysis of research and experimental development. In New Zealand, ANZSRC is used by government, funding agencies such as the Royal Society Te Apārangi, Crown research institutes, universities and independent research organisations. It allows the comparison of research and development data between sectors of the economy. This report currently uses the 2008 edition of the ANZSRC. [See more information](#)¹.

Business expenditure on R&D (BERD)

The cost of R&D performed within a business, regardless of the source of funding.

Business operations survey

This survey collects performance measures from New Zealand businesses to better understand the practices and behaviours that may affect their performance. The 2019 survey included questions on business operations, innovation and international engagement. The survey covers businesses with six or more employees. [See more information](#)².

Centre of research excellence (CoRE)

CoREs are inter-institutional research networks, where researchers work together on commonly agreed work programmes. They support growth in research excellence and contribute to New Zealand's development of world class researchers. [See more information](#)³.

COVID-19

COVID-19 is a disease caused by a new strain of coronavirus. 'Co' stands for corona, 'vi' for virus and 'd' for disease. This disease was formerly referred to as 2019 novel coronavirus or 2019-nCoV.

Crown research institute (CRI)

CRIs are Crown-owned companies that carry out scientific research for the benefit of New Zealand. They include AgResearch, the Institute of Environmental Science and Research, NIWA, Manaaki Whenua – Landcare Research, Plant & Food Research, GNS Science and Scion.

Expenditure	An outflow of money from one entity to pay for goods and services. In this report the term is used to capture the amount of money attributed to research and development conducted in a given sector. It does not necessarily mean the actual amount spent on research and development.
Funding	Money provided for a particular purpose, especially by one entity to another.
Field citation ratio (FCR)	FCR is a citation-based measure of the scientific influence of one or more articles. It is calculated by dividing the number of citations a paper received by the average number received by documents published in the same year in the same fields of research (FoR) category. The FCR is calculated for all publications that are more than 2 years old and were published in 2000 or later. Values are centred around 1.0, so a publication with an FCR of 1.0 received exactly the same number of citations as the average, and a publication with an FCR of 2.0 received twice as many citations as the average. See more information ⁴ .
Government budget allocations for research and development (GBARD)	As defined by the OECD, GBARD includes all spending allocations met from sources of government revenue foreseen within the budget, such as taxation. Spending allocations by extra-budgetary government entities are only within the scope to the extent that their funds are allocated through the budgetary process. Likewise, R&D financing by public corporations is outside the scope of GBARD statistics, as it is based on funds raised within the market and outside the budgetary process. Only in the exceptional case of budgetary provisions for R&D to be carried out or distributed from public corporations would this be counted as part of GBARD. See more in the OECD Frascati Manual 2015 ⁵ .
Gross domestic product (GDP)	GDP is the total monetary or market value of all the finished goods and services produced within a country's borders in a specific time period.
Gross expenditure on research and development (GERD)	GERD is the total R&D expenditure within a country ie the sum of BERD, HERD and GovERD.
Government expenditure on research and development (GovERD)	GOVERD is the cost of R&D performed within government regardless of the source of funding.
Higher education expenditure on research and development (HERD)	HERD is the cost of R&D performed within higher education institutes, regardless of the source of funding.

4. dimensions.freshdesk.com/support/solutions/articles/23000018848-what-is-the-fcr-how-is-it-calculated-#:~:text=It%20is%20calculated%20by%20dividing,published%20in%202000%20or%20later 5. www.oecd.org/sti/frascati-manual-2015-9789264239012-en.htm

Impacts	Impacts are changes in socioeconomic outcomes that are attributable to science and innovation activity.
Innovation	Innovation is the introduction of new or significantly improved goods, services, processes or marketing methods.
MBIE	The Ministry of Business, Innovation and Employment.
National Certificate of Educational Achievement (NCEA)	NCEA is New Zealand's national qualification for senior secondary school students. See more information ⁶ .
OECD-Total	OECD-Total is an indicator for a given variable that is calculated using a weighted average of the values from OECD member countries. See more information ⁷
Organisation for Economic Co-operation and Development (OECD)	The OECD is an international economic organisation. Its 37 member countries represent about 80 per cent of world trade and investment. See more information ⁸ .
Revealed comparative advantage (RCA)	RCA is the proportion of country-specific publications in one field divided by the proportion of publications in the same field globally. RCA values provide a measure of how specialised a country is in a given field of research.
Research and development (R&D)	R&D is creative and systemic work undertaken to increase the stock of knowledge, including knowledge of humankind, culture and society, and devise new applications of available knowledge.
Research and development survey	This survey measures the level of research and development activity, employment and expenditure across all sectors of the New Zealand economy. In 2019 the survey was conducted for the business sector only. The government and higher education sectors are surveyed every 2 years and were included in the 2020 survey. The R&D survey has been collected by Stats NZ since 2006. See more information . See more information ⁹ .
Research publications, publications and scholarly output	These terms refer to individual, published, research documents rather than the journals in which they appear. Research publications are a subset of total scholarly output, which also includes articles, conference papers and reviews.
R&D Tax Incentive (RDTI)	The RDTI operates as a tax credit, rewarding businesses and individuals for performing R&D activities. See more information ¹⁰ .

Sector	A segment of the economy where a number of entities perform similar roles. For the purpose of this report, entities are grouped to fit in business, higher education or government sectors. This grouping is based on definitions defined for international reporting in the <i>Frascati Manual</i> ¹¹ . These definitions deal primarily with the measurement of expenditure, funding and personnel resources devoted to R&D in different sectors.
Small advanced economies (SAE)	SAE are countries in the <i>Small Advanced Economy Initiative</i> ¹² , namely Denmark, Finland, Ireland, Israel, New Zealand, Singapore and Switzerland. These seven countries have economies of a similar size (according to the International Monetary Fund) and populations of 5–10 million.
Science, technology, engineering and mathematics (STEM)	STEM is a broad term used to group these academic disciplines in fields of research or skills. It is typically used when addressing education policy and curriculum choices in schools to improve the competitiveness of science and technology.
Vision Mātauranga	MBIE's policy designed to unlock the science and innovation potential of Māori knowledge, resources and people. <u>See more information</u> ¹³ .

11. www.oecd.org/sti/inno/frascati-manual.htm 12. www.smalladvancedeconomies.org/ 13. www.mbie.govt.nz/science-and-technology/science-and-innovation/agencies-policies-and-budget-initiatives/vision-matauranga-policy/



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New Zealand Government