UNIVERSITY OF AUCKLAND
Waipapa Taumata Rau
NEW ZEALAND

KOI TŪ:
THE CENTRE FOR
INFORMED FUTURES

Research, science and innovation ecosystem

Long-term opportunities and challenges for Aotearoa New Zealand

Briefing for the incoming Prime Minister and Government

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Introduction

Aotearoa New Zealand public-sector science and research badly needs an overhaul that includes a greater appreciation of their role in social, economic, and environmental stewardship and progress. Increasing investment, a focus on its public good and more efficient administration and management are all part of the reforms needed. The multiple threats society faces cannot be dealt with adequately while we continue to be rather passive about public investment in research and use outdated tools to manage and incentivise it. Science is undergoing rapid change. Greater integration of research, science and technology with both higher education and industrial policy is essential.

Key points

- New Zealand continues to fail to adequately recognise the critical role of research and development (R&D) as an investment in future productivity, health, environmental protection, and social development. Its underinvestment compared to relevant comparator countries grows and this increases our disadvantage.
- The separation of policy for research from that in higher education is a considerable weakness. A unified ministry for research, science, technology, and higher education as found in other countries is essential.
- New Zealand is one of few advanced nations that does not have a prime ministerial-led Science and Technology Advisory Council.
- The importance of research to public policy is grossly underestimated. Translational social science including evaluation and implementation science is core to effective and efficient public policy implementation.
- Government departments are variable in their use of operational research and how they contract for research.
- Research funding mechanisms need to be more transparently separated from policy processes and the ownership interests of the Crown.
- Incentives that lead to perverse outcomes in the university and crown research institute (CRI) sectors need to be eliminated.
- MBIE's *Te Ara Paerangi* research, science and innovation reform programme ignores many core issues.
- There are different forms of priority setting for different purposes and the tools to develop research and development priorities vary.
- Research roadmaps developed with multiple stakeholders including Crown agencies offer solutions to how to prioritise many areas of research.
- The roles of multinational corporations, international partnerships and science diplomacy are underestimated as factors in a knowledge and innovations-based future.
- The nature of research is changing and the tools to support it must evolve as well. Transdisciplinary and mission-led scientific research (they not the same) will need different tools to those now being employed.
- Innovation in the science system is stifled by low trust and over-management.
- Industry-support mechanisms are hindered by barriers between universities, CRIs and the private sector; these need to be reviewed.
- The PBRF university incentive system is outdated and dysfunctional.
- There is need for both greater diversity in the research workforce and appreciation of the place of mātauranga Māori within transdisciplinary research.
- Training the research workforce requires significant investment, yet the current approaches to its sustenance are wasteful.

- The importance of more diversity in the research workforce is needed and should not be confused with issues of studying and valuing the mātauranga Māori knowledge base.

Context

New Zealand is a comparatively low public funder of research at the very time science and technology are more important than ever. Digital and post-digital technologies and the life sciences will have fundamental effects on every aspect of our institutions and people's lives. Yet for more than 15 years we've known we are slipping in productivity and many other measures relative to the small, advanced economies with which we compare ourselves. Analysis shows investment in public research must be in the order of 0.8–1 percent of GDP in order to get effective returns, and in turn, drive adequate private-sector engagement. In contrast, New Zealand invests about 0.6 percent of GDP of public funds in research: this figure has not changed significantly over the past two decades.

Science is a human endeavour and yet the system has long been focused more on institutions than on the research community. This is counterproductive and the incentives in the New Zealand public-research sector are misaligned, creating a culture in which the major beneficiaries are the institutes they work for rather than the public. Globally, research valuation and incentive systems are developing to avoid such unintended consequences of past policies.

Instead of a unified system for Crown Research Institutes (CRIs) and universities, the two are treated very differently. The Ministry of Business, Innovation and Employment is focused on its ownership role of the CRIs. For their part New Zealand universities' performance-based research fund (PBRF) is the only remaining incentive system in the developed world that primarily assesses the individual. The continuing nature of CRIs as Crown Companies is a further distinction with interest in budgetary considerations often seemingly greater than the science outputs.

The science system, as a whole, is overmanaged. Emphasis on compliance and commercial goals rather than productivity stifles intellectual innovation. Fundamental change is needed. Disappointingly neither MBIE's *Te Ara Paerangi* research, science, and innovation reform programme nor the Productivity Commission's report on the tertiary sector show a holistic understanding of the system, suggesting that fundamental policy advice is weak. Compounding matters, tertiary policy has become increasingly vocationally focused. This compromises university research culture despite these institutions being the nurseries of the future research workforce for both the public and private sectors.

Public policy needs to be research-informed yet policy relevant: social science and deep environmental research are poorly supported leading to policy inefficiency and knowledge gaps. The system has also failed to clearly delineate those classes of activity that are currently not innovation-focused yet are absolutely necessary for the Crown's stewardship role. New Zealand-relevant discovery-science, along with properly funded stewardship research, are essential for the protection of such national assets as social and environmental monitoring, data curation and the maintenance of collections.

Government departments need to use research better. Operational research, policy trials and implementation science are generally weak components of a departmental portfolio, yet these are key to effective use of the taxpayers' funds. The Integrated Data Initiative and the Social Investment/Wellbeing Agency were an important step in the right direction, but many other sectors of government could use similar approaches. While some of a department's research needs may not require a competitive approach akin to a research grant, but all require quality standards to be met. In many cases there is not the oversight needed to assure that. This may be a role for the departmental science advisor to ensure appropriate mechanisms exist to quality assure. If research roadmaps were properly developed including departmental inputs (and co-funding) then the mainstream funding mechanisms would be appropriate for much of the needed research.

The nature of research is changing meaning that a greater proportion of the research investment will need to be spent on data-related activities (database storage, bioinformatics analysis, curation, access control, data management, compliance and audit functions, etc.) but this should not be at the expense of current investment levels.

The balance between public and private funding of R&D in New Zealand is often characterised in a way that undermines investment. Our economy has few research-intensive large firms, so public R&D spending will remain proportionately higher compared with most developed countries. To thrive smaller research-intensive firms generally need large companies within their innovation ecosystem because of the mutually beneficial flows of human resources and capital between these classes of companies. This dynamic is apparent in the ecosystems of small countries with urban innovation hubs. New Zealand would therefore gain from strategies that build and retain larger companies while also attracting research-intensive multinational companies. However, international evidence suggests for New Zealand to achieve this it needs significantly greater public R&D funding and strategic workforce development.

Evaluation of the barriers between public-sector research and private-sector research suggests the need for change. University and CRI ownership interests and accompanying overhead costs are a barrier. And although there has been progress in expansion of the private entrepreneurial sector, the skills gap calls for revised migration policies. Multinational corporations play a key part in innovation systems yet New Zealand is wary of them. Again, this contrasts with other small, advanced economies. One green shoot is the arrival of overseas cloud-computing platforms. However, the Callaghan Institute and New Zealand Trade and Enterprise may need to be reviewed to become more effective at fostering innovation.

New Zealand has both moral and constitutional responsibilities towards Māori. Mātauranga Māori is an indigenous knowledge system of very significant value. However, to combine and conflate indigenous and mainstream approaches through the research system's funding mechanisms is problematic to both. A structure is needed that funds research in and using mātauranga Māori without ignoring or blurring the distinctive nature of these knowledge systems with what is recognised globally as science. Nor should a research system require every basic science research proposal to include Māori-specific content. A study of the biological processes involved in the growth or disease-susceptibility of a pine tree, for example, would be the same whether it is undertaken in Aotearoa New Zealand or in the USA. However, if the research were to involve genetic experimentation or field trials in specific locations, it is clear that issues of local and indigenous values, knowledge and worldviews would come into play. An approach involving the blanket application of mātauranga Māori risks diluting its importance and value and frustration.

Quite separately, career structures for Māori and other underrepresented groups must be included in the science system.

No small country alone can do everything in science and indeed science is seldom conducted in isolation from the international community of scholars and innovators. But our geographic isolation makes science-collaboration hard. Our international science funding and co-operation system is weak and not very strategic; yet given our isolation, we arguably need a strategy for accessing international science more than any other advanced country. Developments with Horizon Europe are welcome, but there is a need to expand our partnerships beyond Europe. The Catalyst Fund is grossly inadequate and narrowly focused.

Towards more effective policy formation and management in the science and research sector

At present tertiary education policy is set by the Ministry of Education rather the Tertiary Education Commission, whereas in many other countries higher education policy sits alongside science policy within a single ministry. We see as a priority the creation of a new ministry to cover policy and give oversight of public research in science, research, and higher education. The proposed New Zealand Ministry of

Technology could well fit under the same umbrella: this proposed ministry should be distinct from MBIE and the Ministry of Education.

Science is key to virtually every decision a government must make and most advanced countries now have a prime ministerial or presidential Science and Technology Council. These mostly comprise people active in the science community and are distinguished from innovation and economic councils that are largely private-sector groups.

The New Zealand research, science and innovation (RSI) system is overly complex with six significant public funders: the Health Research Council, MBIE, Callaghan Innovation (declining as tax credits take over), the Marsden Fund (administered by the Royal Society of New Zealand), the Centres of Research Excellence (administered by the TEC) and 10 National Science Challenges (the latter allocating significant amounts of CRI funding although this was not intended to be the case in the original policy). To that there are other Crown-owned bodies such as ACC, EQC and the Lottery Board also providing competitive research funds. The inadequacies of this messy model include funding gaps and duplication and a confounded science sector.

Demarcation uncertainty between CRIs themselves, excessive competition and the funders' numerous decision makers have created a capricious and incoherent system. A new model based on the maxim that "second-rate research is a waste of money" needs to take its place.

Mission-led research such as that of the National Science Challenges requires discretionary money but it must be applied directly to the mission. In many cases this reflects the "mission-moonshot" approach to addressing a specific outcome/challenge. This was the initial policy intent of the NSCs at the outset, and has been lost.

The CRIs' corporate model means they are increasingly driven by managerial considerations, an affliction that universities also suffer from. In part this may be due to the 1990s' neoliberal shift but it also reflects a growing lack of trust in the science agencies and ongoing confusion about their roles. For example, at least five CRIs have an interest in freshwater, as do most of the universities. Yet they operate with incentives that counteract collaboration. Our country is too small for such a hyper-competitive model.

CRIs and universities could be funded in more accountable and strategic ways if overhead costs were removed from the competitive funding system or limited to covering operational requirements, and capital needs were met by grants.

But there is a deeper question about the CRIs, which originally sprang from the Department of Scientific and Industrial Research and the research component of the Ministry of Agriculture and Fisheries. It is not obvious that seven separately managed small (by global standards) research organisations are needed. Australia and Singapore, which have large research-institute ecosystems, use integrated management and governance authority allowing the delivery units to focus on scientific value.

New Zealand's CRIs remain largely apart from and often competitive with universities because of their different mandates, employment structures and expectations. In some areas it is less obvious why ongoing research is being conducted outside the universities where the links to workforce development are stronger. If incentives were to be aligned better to both the universities and the CRIs then collaboration would only grow. A braver innovation would be complete integration as has occurred in Denmark.

Priority setting

Priority setting occurs at many levels, yet *Te Ara Paerangi* is silent on these. At the top of the pyramid government decides how much to spend on R&D, which relates directly to broader policy priorities. Macro-prioritisation then determines how much should be invested in the university sector, the research-institute sector and on private-sector research. At a lower level the balance of health, environmental, social science and industrial-support funding is struck. And beneath that, funding is allocated to the remainder of activities across Pasteur's quadrant[1] as well as such issues as workforce development and maintenance.

1 Pasteur's quadrant refers to a highly influential analysis reflected in the OECD's Frascati Manual and categorises research between pure basic research, use-inspired basic research, purely applied research and development while not being trapped in the linear model that assumes a direct relationship between discovery and application: a model which remains rather imbedded in much of the policy community.

At that level planning and decision-making turns to specific funding tools including programmes, career development, projects and transdisciplinary platforms.

Long-term research road maps are perhaps the best guide for the research community, an example of which is the Conservation and Environment Roadmap developed after detailed consultation (MFE, 2017). But, as was pointed out by the Commissioner for the Environment, it was never incorporated into the policies used by the research funders (PCE, 2020). Nonetheless the generic road-map model may be the most useful prioritisation tool in a small and fractionated system.

Stakeholder priority setting is a constant issue for funding as usefully illustrated by the HRC experience. When it tried to prioritise funding allocations by demographic and disease incidence, the priority list soon included virtually everything the HRC was undertaking at the time. The External Advisory Group for Health Research[2] then took an alternative approach by asking the question "why do the research in New Zealand?", recognising that a small research system cannot do everything. Prioritisation must detemine the need to answer a specific question, the opportunity to initiate unique work and in the end, to have some basic capacities for knowledge capture and workforce development. Of course, circumstances and technology opportunities can change quickly in science, borne out by Covid and the development of CRISPR genetic techniques, so any prioritisation system must allow for flexibility and responsiveness.

Mission-led science is just one way to prioritise efforts and generally requires a clear objective. Small economically advanced countries tend to have a higher fraction of their investment in mission-led science in part so as to have a significant presence in an area of focus. Increasingly, and as identified by the OECD (OECD, 2020) and the International Science Council (ISC, 2021, 2023), mission-led science is central to transdisciplinary and systems-based research approaches aimed at addressing "wicked problems" such as land-use sustainability that by its very nature requires disparate contributors.

Research assessment is central to any science and research system. It ultimately determines who and what is funded and is thus part of prioritisation as well as micro-scale project allocation decisions. It provides the indicators that shape research outcomes. However, it is not always clear how such terms as "excellence", "impact" and "relevance" are applied. Therefore, extensive global experience shows the importance of transparency in these matters. Whatever the flaws, peer review remains the primary tool of research assessment. But in a small country there are dangers of conflicts and unconscious bias. Many small countries of comparable standing only use external reviewers to avoid these issues when considering research excellence. This approach needs consideration in New Zealand, with mātauranga Māori research being an exception.

Towards more efficient operation

In 2011, the Foundation of Research, Science and Technology was absorbed into a Ministry of Science and Innovation before becoming part of MBIE in 2012 with funding known as the Endeavour Fund and SIFF (the science infrastructure fund). This saw a significant reduction in the separation of policy from independent research assessment. It has since become apparent that the structure of the Endeavour Fund, Marsden Fund, HRC and various smaller sources of money administered by the NSCs and others lack inherent logic earning inspiring one senior scientist to describe it as a sprawling "beauty contest". The UK, in contrast, uses a model with a single administrator, the UK Research Institute, which acts through seven disciplinary councils. Sector co-ordination of research is paramount allowing for prioritisation based on programme intentions upstream and downstream research outputs as well as career development and diversity issues.

In this country it is conceivable that the Endeavour Fund, HRC, NSCs and TEC-funded CoREs could share infrastructure and back-office functions. This could channel funds to medical and health research, the social sciences, humanities and the creative sector, environmental sciences, biological and natural

2 The IAG was a group established to report to MBIE and Ministry of Health with a mix of global and domestic experts on all aspects of health research including that by DHBs and the ministry and was active in 2018–2019. It reported the Ministries and their ministers.

sciences, digital and other technologies, mātauranga Māori and transdisciplinary research. The Royal Society-administered Marsden Fund, with its distinctive legitimacy in the academic community, may be a special case, but could nevertheless also be integrated into this model.

Arguably the biggest constraint to New Zealand science is the ubiquity of small and increasingly constrained project grants. Global experience has shown that scientists often make their biggest breakthroughs on the margins of such funded activities. But underfunded science inevitably becomes conservative. This can hold back progress and make it especially difficult for early-career researchers to make a mark.

Without more funding, and given the small size of the public-science sector, we will continue to fund conservative research when innovation requires an intellectual entrepreneurial approach, impede career development and fail to advance important scientific activity. At the same time new modalities must be supported, including data curation, cost-incurring open science; transdisciplinary activity and opportunities for career development. Such requirements all point to increased research costs. Prioritisation of funding must take account of all these considerations, hence the need for a transparent and high-quality process that the science community and end-user stakeholders can have confidence in.

The missing pillar: taking science education seriously

Science education has two essential roles. Firstly, it empowers the next generation to question, investigate and act, which are essential contributions to a better future. Secondly, developing and using knowledge appropriately is core to national progress, and every nation needs a workforce competent to thrive in a technological age across a broad range of vocations.

Thus, investment in science education in a way that promotes the development and application of scientific literacy and generates enthusiasm for scientifically orientated career paths from an early age is an indisputable priority.

There are big lessons to learn from the Nordics, Singapore, other East Asian countries and particularly China – they take science education seriously from the earliest age. They have recognised that they cannot progress without broad scientific literacy and a workforce competent for a knowledge-based and technology-based economy.

New Zealand, on the other hand, has taken a passive approach. The result has been that many of our children have not been provided with some of the core competencies required to thrive in a science-driven and rapidly changing world.

The degradation of science education in New Zealand has occurred over several decades with critical decisions by successive governments to underinvest in enabling the science curriculum. Science education and education more generally have become a misleading battleground for other political agendas.

Science education in primary schools is minimal and seldom supported by specialist primary science teachers – yet the experience overseas shows how that makes a real difference. Further, New Zealand has underinvested in teachers and their development and is faced with a crisis of attracting and maintaining teachers, particularly science teachers.

It is vital that children in the critical age window 11–14 years are not turned off science, perceiving it as being too hard or not relevant. Science is made an optional subject far too early in compulsory education. The importance of science and the value of a science education is poorly understood and not encouraged or actively sought by all parents, guardians, and whanau.

Science and creativity have been inappropriately disconnected. Informal science education programmes can provide interactive, engaging and hands-on opportunities for children to develop critical thinking and problem-solving skills. These ideas are well established overseas and accessible

for all. The results speak for themselves. In New Zealand, these programs are generally only available to higher-income families, creating significant disparities in access and further exacerbating existing divides. Exciting green shoots such as mobile science labs/museums and the Nation of Curious Minds have not been exploited or expanded. Indeed the broader science literacy and engagement programme, the Participatory Science Programme which was designed to partially address these issues has in the last weeks just been terminated by MBIE. We have not invested in high-quality science museums or used public broadcasting funds to produce locally derived programmes in science.

New Zealand is not performing well in the face of global competition for knowledge and its potential as a wealth generator. The success of New Zealand in growing the knowledge economy will need deliberate action now to ensure that New Zealand has a pipeline of talented and diverse workforce to meet the challenges of the future.

Actions for consideration

- **Recognise that it is not in New Zealand's interests to continue as a low funder of public R&D.**
- **Establish a prime ministerial Science and Technology Council.**
- **Create a ministry combining the science and research responsibilities of MBIE with the university responsibilities of the Ministry of Education.**
- **Promote the need for operational research, policy trials and implementation science in government agencies.**
- **Reduce the overlap and redundancy of research administration by having a single New Zealand research council for managing funding of research.**
- **Consider amalgamating the CRIs into a single management entity.**
- **Provide funding for mātauranga Māori separately from the research workforce funding.**
- **Develop a clearer understanding of the many levels of priority-setting.**
- **Develop mechanisms to support social science, transdisciplinary and mission-led research.**
- **Review the full-cost funding model to allow better management and oversight of infrastructure.**
- **Give greater priority to investing in international science partnerships and opportunities.**
- **Take a more integrated and holistic view of the research workforce, its development and maintenance.**

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Koi Tū: The Centre for Informed Futures is a research centre and an independent, non-partisan think tank at Waipapa Taumata Rau, University of Auckland with associate members across New Zealand and the world.

We address critical long-term national and global challenges arising from rapid and far-reaching social, economic, technological, and environmental change.

Our name, Koi Tū, was gifted by Ngāti Whātua Ōrākei. It means 'the sharp end of the spear'. Like our namesake, Koi Tū aims to get to the heart of longterm issues challenging our future.

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We engage with people and organisations focused on the long-term development of New Zealand, and on core issues where trustworthy and robust analysis can make a real difference.

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