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15 March 2022

Response to Te Ara Paerangi – Future Pathways Green Paper

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Abstract

The Green Paper is timely and welcomed but it does not address many of the core issues associated with using science and research to advance Aotearoa New Zealand. It avoids addressing the higher-level policy framework under which science and research operate – a framework that has not substantively altered since the policy reforms of the 1990s. Further, by limiting the review to substantively exclude consideration of more than half of the sector, the Universities, it constrains its value. This commentary, which is made from a rather uniquely informed position suggests, that a starting point would be:

- Formation of a ministry combining the science and research responsibilities of MBIE with the University responsibilities of the Ministry of Education.
- Reducing the overlap and redundancy of research administration by having a single New Zealand Research Council.
- Separating policy from funding decisions more completely and transparently
- Recognising that it is not in New Zealand's interests to continue as a low funder of public R&D.
- Addressing the need for support of Mātauranga Māori via a discrete funding route thereby distinguishing between supporting Mātauranga Māori from supporting diversity of the research workforce.
- Developing a clearer understanding of the multiple levels of priority setting.
- Developing mechanisms to support social science, transdisciplinary and mission-led research Amalgamating the CRIs into a single management entity.
- Reviewing the full cost funding model to allow better management of infrastructure.

- Giving greater priority to investing in international science partnerships and opportunities.
- Taking a more integrated and holistic view of the research workforce, its development and maintenance.

Preamble

I make this submission as an individual, but I hope my roles both locally and internationally over the time since the last major review and restructuring in 1992 allow me to stand back and look holistically at issues, in a way that is overdue[1].

It is critically important that the science and research system is subjected to a periodic rethink and the Green Paper opens the door for such activity, but its scope is unfortunately too narrow and operationally framed for it to adequately meet the intended objectives. Undoubtedly, a substantive rethink is well overdue given that the central role of both the natural and social sciences in the nation's development and protection. The circumstances have changed greatly since the fundamental reforms of 1992 which saw the CRIs formed along with the creation of a dedicated ministry (now combined into a much larger entity).

[1] I currently hold a Distinguished University Professorship in the University of Auckland where I head the Centre for Informed Futures, New Zealand and I am the Chief Scientific Officer of the Singapore Institute of Clinical Sciences (2007 to now). I have honorary chairs at the University College London, University of Southampton and National University of Singapore. My career was launched as an overseas fellow, then repatriation fellow, then a senior research fellow, then a career fellow of the old Medical Research Council. I was Executive Dean of the Faculty of Medicine and Health Sciences (1992-2001) and founding Director (2001-2009) of the Liggins Institute of the University of Auckland. I headed the Centre of Research Excellence, the National Research Centre for Growth and development 2004-2009. I have published over 750 scientific papers. I co-chaired the WHO Commission on Ending Childhood Obesity (2014-2017). I chaired the External Advisory Group on Health Research in New Zealand (2018-2020). I chair the international advisory panel to the Future Research Assessment Programme of the UK which reviewed the UK equivalent of the PBRF. I am a member of the Advisory Board to the Geneva Science Diplomacy Anticipator which is think tank supported by the Swiss Government to focus on emerging technology trends. I was the foundation president of the International Society for Developmental Origins of Health and Disease (2003-2009). I am a Fellow of the Royal Society of London (2001) and the Royal Society of New Zealand, a member of the National Academy of Medicine (USA, 2004), a Fellow of the Academy of Medical Sciences (UK, 2006), a Fellow of The World Academy of Sciences (2021). From 2009-2018 I was first Chief Science Advisor to the Prime Minister of New Zealand and from 2014-2018 was science envoy to the Ministry of Foreign Affairs and Trade. I headed the secretariat of the Small Advanced Economies Initiative from 2012. I was the foundation chair of the International Network of Government Science Advice (INGSA) (2014-2021) and president of the International Science Council (ISC) (2021-2024). I was awarded CNZM in 1996, DCNZM 2008 redesignated as KNZM in 2009. I was made a member of the order of New Zealand (ONZ, 2015) and received the Rutherford medal in 2001. Amongst international awards I was awarded Singapore's highest scientific honour, the Presidential Science and Technology medal in 2021 and the American Association for Advancement of Sciences Science Diplomacy award in 2016.

Since 1992 there has been much tinkering and *ad hoc* decision making, in many cases counterproductive or in some cases with negative spillover effects. For example: the 2010 review of the CRIs (the Jordan Report) led to the needed development of core funding of CRIs, which was subsequently undone without the policy implications being fully understood. From that review, the rapid merger of MoRST and FRST which has had negative implications with the transparency of funding decisions being lost. Another example was the *post-hoc* conversion of the national science challenges into something resembling ten new and autonomous mini-funding regimes.

Regrettably, the Green Paper consultation appears to be too narrow to achieve what should be the primary purpose of a substantive review. i.e. to ensure we have a science and research system that promotes New Zealand's human, social, environmental, and economic development over coming and challenging years.

Some of these challenges include the inevitable shift away from current forms of primary production, dealing with the emergence of new digital and life science technologies[2], our persistent low productivity, growing inequalities and the need for New Zealand to develop a more weightless export sector. Further, the nation must confront a number of major challenges and perennial issues including: climate change, environmental degradation, major social and economic change, demographic change, intergenerational disadvantage, and the need to address what the country's bicultural, yet multicultural future while confronting a generally more unstable world.

Thus this opportunity for a more extensive rethink is needed some 30 years after the last fundamental changes (which even then was arguably too narrow). The pace of change in the role of science has accelerated and we face new and wicked problems: highlighted by Covid, climate change, emergent concerns over social cohesion and the technological revolution. In this context it is critical that the role of knowledge development and application is reviewed.

While often denied, or at least over-looked by the policy community, the comparative evidence is robust: investment in R&D, particularly upstream public investment, is key to economic growth[3].

This submission is intentionally at a high level as the Green Paper dives too quickly into asking about specific operational detail which is premature. The questions asked focus rather narrowly on one aspect of the science system which has already made much progress – namely recognition of the Treaty and its obligations. Without diminishing the importance of such aspects, it is important to think much more broadly about the role of science and research in New Zealand's future.

[2] See www.gesda.global for insights into trends in technology development we must consider

[3] Mariana Mazzucato; the Entrepreneurial State: debunking private vs public sector myths 2015

I am happy to provide further detail or justification any of the points raised.

Part A GENERAL COMMENTS

1.The key questions not asked

There are some critical questions which are not discussed:

1.1 The intervention logic

New Zealand remains a low funder of research by global standards, at the very time science and technology are manifestly more important than ever to New Zealand's people, society, economy, environment, and global connectivity. There is much change afoot; this is likely to impact on the shape of the country's society, and economy[4]. Digital and post-digital technologies and the life science technologies will have fundamental effects on every aspect of the New Zealand institutions and how people live their lives. Given these inevitable futures, it is critical that a more integrated policy assessment is undertaken than offered by the Green Paper.

Thus, there are some fundamental questions that need to be asked first. A policy review should focus on *function* (which is incompletely and minimally discussed) before *form* (which is where much of the paper is focused). Thus, some of the key questions must initially concentrate on function.

Why should New Zealand invest in R&D?

The answer to this would seem to be self-evident, given extensive international evidence that basic and applied research must be conducted in country to drive its human and economic development. Analyses show clearly that investment in public research must be in the order of 0.8-1% of GDP to get returns including adequate private sector engagement. Regrettably, New Zealand public policy attitudes have over decades refused to recognise the immediacy of such investments. Indeed, it is sometimes stated by some Treasury officials that there is reverse causation; only rich countries can afford to do such research. On the contrary, Singapore, Israel, Ireland and the Nordics have all unequivocally demonstrated that proactive investment in all forms of research from the public sector pays dividends in multiple ways. Furthermore, during extensive consultation over the past decade I have found no expert economist offshore that would accept this skeptical position that has had such a negative influence over decades of New

[4] See Gluckman P 2021: https://informedfutures.org/transitions-transformations-and-tradeoffs/

Zealand policy-making regarding R&D. Indeed, the OECD would argue that a country like New Zealand should invest even more urgently because of the extra impost of distance and location.

It is unfortunate that New Zealand has generally taken a constrained view of research, focusing more on the incentives related to downstream innovation and short-term financial returns while largely starving those social, environmental and stewardship[5] sciences where so much public good emerges. The system has not adequately or systematically recognised those classes of activity that are not innovation focused. Discovery science is essential to New Zealand as well as properly funded stewardship science for the protection of the nation's assets including social and environmental monitoring, data curation, collections etc.

What is distinctive about research in New Zealand?

New Zealand has distinctive domestic and international obligations and responsibilities in research. This includes that research which relates to the natural and built environments including the marine estate, fauna and flora and the land environment *per se*. Similarly, there must be high quality research into its peoples and neighborhoods as well as that relevant to the economy and the scourge of poverty. Undeniably, such requirements on top of the ability to partake in and absorb new knowledge developed globally must lead to greater not reduced research investment. In short, New Zealand must be a first world country generating knowledge, not just consuming it.

The balance between public and private funding of R&D in New Zealand is often misinterpreted and in a way that undermines investment. The shape of our economy with the small number of research-intensive large firms is such that until this situation changes (if ever), public investment in R&D will be proportionately higher as a fraction of the total research intensity compared to most developed countries. This is simply because large multinationals fund 70% of global R&D and particularly in those sectors not well represented in New Zealand (defense, heavy engineering, pharmaceuticals, ICT etc.). Indeed, smaller research-intensive companies generally need large companies within their innovation ecosystem to thrive because of the iterative relationship in both human resources and capital flow between these classes of company. This is well demonstrated in the ecosystems of small countries and their urban innovation hubs in Europe, Israel, and Singapore .

Importantly, when New Zealand research investment by small and medium enterprises is considered, their investment is at the OECD average. Strategies to build and retain larger companies and attract research intensive multinational companies would be needed to change

[5] By stewardship sciences I refer to that set of sciences necessary for national stewardship: data collection, collection management, base observations, biosecurity monitoring etc. that are critical for societal informed decision making in stewardship of our human, social, cultural, and natural resources.

the relationship significantly and in turn, international evidence points to the need to have a significantly greater public funding of R&D to achieve that.

The Green Paper correctly points out the need to undertake research across more than one knowledge system. The paper recognises the moral and constitutional responsibilities toward Māori. Mātauranga Māori is an indigenous knowledge system of significant value in multiple ways. However, to combine and conflate indigenous and mainstream epistemologies through the research system's funding mechanisms is problematic to both. Further, as Dr Charles Royal, author of the original Vision Mātauranga approach within MBIE points out in his own submission, the intent of Vision Mātauranga has been significantly affected by actions of MBIE itself and this has led to further confusion.

A structure needs to exist to fund Mātauranga Māori but this should not ignore or blur the distinctive natures of these knowledge systems. Nor should it require every basic science research proposal to include Māori-specific content. For example, a study of the biological processes involved in the growth or disease of a pine tree would presumably be the same irrespective of whether it is undertaken in Aotearoa or in America. 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, knowledges and worldviews would come into play, and researchers who do not already understand the issues would need to source the expertise. The point is that a blanket approach to the application of Mātauranga Māori risks diluting its importance. To be sure, all *researchers* – no matter how fundamental or applied is their science – must be equipped and enabled to judge whether and how their work interacts with Matauranga and Te Ao Māori. But this should not imply that all *research* would automatically need to be Matauranga enabled.

Beyond Mātauranga expertise, however, career structures for Māori and other underrepresented groups, must be included in the science system.

No small country can do everything in science alone. Indeed, there is very little in science that is done in isolation from the international community of scholars and innovators. Furthermore, our geographical isolation and lack of membership of the G20 makes for substantive difficulties for science collaboration. Our international science funding and cooperation system is very weak, yet New Zealand, more than any other advanced country given its isolation, needs an active strategy for enhancing access to international science. I note with some hope that the nascent discussions with the European Commission have finally started and should extend to the European Innovation Council.

R&D is an investment not a cost.

The considerations outlined above should allow a more urgent response to the question of research investment. There is consensus, as reflected in previous party manifestos across the spectrum, that New Zealand is not investing enough in R&D; but despite such rhetoric New Zealand remains as the poorest investor in public R&D of any small, advanced economy. While it is stated that we invest ~0.65% of GDP in R&D, this is far less than comparable countries and indeed, this number is inflated by the inclusion of funding sources such as the PBRF which is not primarily a research support fund[6]. The Green Paper correctly expands the domains in which public good research areas required. However, this simply will not be achieved based on current government research spending patterns.

The generally accepted target in Europe is 1% of GDP on public expenditure on R&D with a goal of an overall research intensity of 3%. Naively public policy in New Zealand continues to assume that the goal of 2% research intensity will largely be met by the private sector but this takes no account of our corporate mix and the lack of large companies in our ecosystem. European experience suggests until public expenditure is more than ~ 0.8%, private sector investment will not increase beyond roughly that of the public sector.

1.2 The missing component: the University sector?

The weakness of the paper is highlighted in its admitted exclusion of the role of the largest part of New Zealand's public facing research system, namely the universities. As a result, the total ecosystem cannot be fully analysed. The Productivity Commission in its review of the tertiary sector[7] also left research out of their analysis. To look at the science system without the universities is illogical and has been a recurring policy failure in New Zealand.

This omission is even more problematic because the CRIs, which appear to be the real focus of the Green Paper, provide only a segment of New Zealand's needs. They do not cover most health research, many domains of environmental research and virtually all social science. Neither are the CRIs mandated to conduct extensive discovery or natural science research and certainly not in the digital sector, the creative sector, or the humanities.

Furthermore, discussion of research in universities rapidly reverts to the PBRF, which is both a gamed and outdated incentive scheme which weights university base funding to certain incentives and objectives as is the case for similar dual funding schemes globally.

To compound matters, tertiary policy has become increasingly vocationally focused and the research cultures of universities in New Zealand are increasingly compromised, despite being the generators of the future research workforce for both the public and private sectors.

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[6] The PBRF is a device to dual fund universities providing an incentive tool to the Crown and is not used primarily by universities to directly support research.

[7] https://www.productivity.govt.nz/assets/Documents/2d561fce14/Final-report-Tertiary-Education-v2.pdf

1.3 Clarity of policy formulation

In New Zealand, the policy component of tertiary activity is based with the Ministry of Education, with the TEC having no core policy role. This is contrary to the design in many countries where Higher Education policy sits alongside science policy within a single ministry.

An exploration of post-1992 science policy organisations in New Zealand shows instability. Whereas the original Ministry separated the formation and implementation of R&D policy from funding choices, that Ministry (MoRST) was merged with FRST (the funder/implementer) in 2010 with very unfortunate perceptional, if not actual, conflicts and unintended consequences. The merged entity became the short-lived Ministry of Science and Innovation (MSI). This new ministry was, in turn, merged rather soon after into MBIE – a super ministry - against much advice (including my own) from the science community. In creating the merger with MBIE, a distinct presence for of science and research within the New Zealand policy landscape completely vanished such that the relevant DCE finished up with an extraordinary range of disparate responsibilities (including aspects of regional development, refugee policy etc.).

The merger of MoRST with FRST, an unanticipated result of the 2010 CRI review, led to the loss of separation of policy formation from research assessment and funding decisions. While the science board of MBIE, a device developed as a supposed firewall, is claimed to offset that short-coming, there is sufficient anecdotal and observational evidence to suggest that other criteria beyond quality and relevance enter the funding decisions. A perception has emerged that some funding decisions are made to ensure CRI viability. The Science Board is invisible to much of the science community, and fairly or not, is not seen to have real oversight or influence.

Similarly, when an early review of the National Science Challenges suggested poor performance, political considerations stopped a more significant revision of a well-intended but poorly delivered scheme. Only in command economies and in low-income countries are funding decisions in science made by the same organisation that sets science policy, and which is directly under political control. Even the symbolism of government ministers announcing research funding outcomes in New Zealand has raised eyebrows in the international science community.

Part B SPECIFIC ELEMENTS

2. Fragmentation and too many decision makers, too much management; the resulting overhead challenge

The current research, science and innovation (RSI) system has six significant allocators of public funding to research these being HRC, MBIE, Callaghan Innovation (a declining role as tax credits takeover), the Marsden Fund (administered by the Royal Society of New Zealand), the Centres of

Research Excellence (administered by TEC) and the ten National Science Challenges (which have significant amounts of funding shifted from CRIs to them although this was never intended to be the case in the original National Science Challenge cabinet-approved policy). There are significant issues with this messy model that cause both gaps and duplication. The most obvious gaps are in poor funding of social sciences, of stewardship research (and duplications in medical and health research. The Marsden fund, sometimes called a blue skies research fund, has had its scope extended in recent years.

Competition between CRIs, uncertainty as to the boundaries of each other's responsibilities and the overly competitive nature of a funding system, together with multiple uncoordinated decision makers (e.g. in the NSCs), has resulted in a system that is increasingly capricious. The focus into the future must be on high quality research given the maxim that second rate research is a waste of money.

Mission-led research such as that of the NSCs or the CoREs require discretionary money, but it must be applied directly to the missions they are addressing and at least in the case of the NSCs, it is apparent that in many cases, they have lost sight of the "moonshot" approach to address a specific outcome through research that was the intent of the original.

Science is an activity of intellectual creation supported by technology. It is increasingly involving multiple domains, disciplines, and larger teams. Short-term funding inhibits that evolution. The CoREs and NSCs were created in part to address this issue and promote inter-organisational collaboration. But the NSCs became yet another layer of management with large overheads driven by other agendas rather than promoting the scientific aim: they are now acting as small and autonomous funding agencies in their own right. This is overly complex, bureaucratic and undermines quality; further this has disrupted many CRIs.

Generally, the CRIs have been increasingly driven by managerial considerations (given their corporate model) rather than addressing science issues which could be better elucidated in their Statements of Core Purpose. This affects their internal culture. Similarly, the Universities in New Zealand have also become dominated by managerialism. Part of that may be inevitable given the neoliberal shift of the 1990s in which the context of these institutions was framed, but part of it also reflects a low trust model and confusion of roles. For example, at least five CRIs all have an interest in freshwater as do most of the universities. Yet, many of the incentives now in play counteract collaboration.

New Zealand is too small for the hyper-competitive model we have. Part of that is primarily due to the comparatively low level of funding available which has not kept up with growth of the Higher Education sector, the incentives in play institutionally and individually, and the increased expectations of science for society. The outdated New Zealand PBRF model is excessively focused

on bibliometric outputs rather than on broader aspects of engagement and impact. Overall, the New Zealand system is focused on individual performance rather than team-based activity[8].

With the CRI business model and the state of the universities, the competitive fight for overhead-driven research funding takes precedence and creates negative spillover effects and behaviours. The concept of full cost funding as applied in New Zealand is different to that in most other countries (the USA is distinct for multiple reasons). In most comparator countries, research is not full cost funded in this way – overheads are generally limited as capital costs are handled differently. The current model was introduced in the late 1990s to the University component after being established in the CRIs when they were formed. If overheads were to be removed from the competitive funding scheme or limited to operational requirements, with capital requirements handled differently (for example by a capital grants fund or funds to both Universities and CRIs), this would allow CRIs and the universities to be funded in more accountable and strategic ways. Such a model would also confer to the government a greater ability to stop unnecessary or duplicative capital expenditure by universities and CRIs.

A further distinctive issue in New Zealand is the requirement for major research equipment to be subject to depreciation off the same grant that purchased it. This effectively charges the research budget twice for the equipment. This is illogical in multiple ways – not the least being that as technology rapidly develops the likelihood of upgrading is diminished. Effectively, the current model ensures that science in New Zealand is slow in accessing cutting-edge equipment.

This leads to a deeper question. The CRIs were developed from the closing of DSIR and MAF-Research. They remain largely separate from (and often competitive with) universities, for the simple reason their mandates, employment structures and expectations are different. The importance of CRI activity is abundantly clear in some areas. However, in other areas it is less obvious why ongoing research is outside of the universities where the link to workforce development is much stronger.

The mix of CRIs has shifted since their formation. Notably, one in social sciences was abandoned at an early stage, and two others were merged to create Plant and Food Research. On several occasions larger mergers have been mooted. It is not obvious that the current mix is optimum and whether seven rather small (by global standards) research organisations are needed in that they demand an unnecessarily expensive and duplicative management layer. Australia and Singapore, which have large research institutes, use a single management and governance authority allowing the delivery units to focus much more on scientific value rather than managerial oversight. Ideally, such a structure would reduce management costs, allow for greater

[8] I chair the international advisory review committee to the UK equivalent Future Research Assessment Programme (FRAP) which is very differently orientated.

clarity about who does what, avoid duplication and create a research entity of a size that can better identify needs and gaps. If incentives were to be aligned better with universities, then collaboration would only grow.

3. Priority setting

Priority setting is essential in a small country that cannot do everything. What issues are addressed and how has enormous long-term implications for New Zealand. The issues around priority setting cannot be separated from how policymaking in research is conducted and how this relates to the overall strategic direction defined by the Crown. The lack of clear industrial policy is one obvious example of a policy gap.

The choice of one area of research over another demands justification in New Zealand's small and resource-constrained RSI system (see Appendix).

Priority setting occurs at multiple levels, yet the Green Paper is rather narrow in its viewpoint. At the highest level it is the decision of the government to determine how much to invest in R&D and this in turn relates directly to broader policy priorities. Then there is a macro-prioritisation issue of how much it wishes to invest in the university sector, in the research institute sector and in private sector support. It then follows that decisions need to be made about the balance of health research, other domains of research (e.g. environment, social science), and industrial support, etc. At a lower level there is the need to investigate the balance of activities across Pasteur's quadrant[9] as well as issues such as workforce development and its maintenance. Only then can planning and decision-making turn to the more operational issues about the nature of specific funding tools (programmes, career development, projects, transdisciplinary platforms etc.) are the priority.

In some areas there is the need to identify where in Pasteur's quadrantis the country's sweet spot. The location of that may be contested by different stakeholders. Such requirements need appropriate policy work, transparency, and delegation as appropriate ranging from ministries to responsible agencies. But with a small overall budget in relative terms, there must be alignment between the decision-making entities on priorities.

Research in general is a long-term activity. By way of an example: agricultural research in New Zealand should now be focused on the future of pastoral farming systems 20 years hence. This will need to develop climate change-informed strategies that will allow the sector to remain

[9] Pasteur's quadrant refers to a highly influential book published in 1997 on science policy by Donald Stokes entitled "Pasteur's Quadrant, basic science and technological innovation" which is also 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

attractive to the global consumer. Economic research should be focused on aspects of adjusting the New Zealand economy to those new realities.

Long-term research road maps are perhaps the best guide for the research community. The Conservation and Environment Roadmap was extensively developed after detailed consultation[10] but as the Commissioner for the Environment[11] pointed out it was never incorporated into policy used by the research funders. Irrespective, the generic model of roadmaps may be the most useful tool in a small and fractionated system.

But there are always issues in priority setting as to which stakeholders have the greatest voice in setting priorities and which tools may be applied to meeting those priorities. Hence the need for very clear research policy mechanisms with a high level of transparency. The HRC experience provides a useful example. When it tried to prioritise by demographic and disease incidence, the priority list soon encompassed virtually everything the HRC was undertaking. The External Advisory Group for Health Research[12] then took a different approach pointing out the very different ways prioritisation may be defined – in setting the question "why do it in New Zealand" (relating to the point that with a small research system, not everything can be done). An extract from its report is attached as an appendix and illustrates the type of thinking that could go into prioritisation. Prioritisation must distinguish between where new knowledge is needed to tackle a specific issue and where it is recognised that the logic is to address a missing domain of activity; the tools needed are quite different in these two situations.

Things can change very quickly in science because of circumstances (Covid is a good example) or technology (CRISPR is an example) and any prioritisation system must allow for flexibility and responsiveness.

Mission-led science is but one way to prioritise and generally requires a clear objective. Small economicallyadvanced countries tend to have a higher fraction of their investment in mission-led science in part to have a significant presence in an area of focus. However relative comparisons are often distorted because such countries generally have a low defence R&D spend.

Increasingly, as identified by the OECD[13] and the International Science Council[14], transdisciplinary and systems-based approaches are core to mission-led science aimed at addressing 'wicked problems' such as sustainability. Currently the International Science Council has a Commission

[10] https://environment.govt.nz/publications/conservation-and-environment-science-roadmap/
[11] https://www.pce.parliament.nz/publications/environmental-research-funding-review
[12] The IAG was a group established to report to MBIE and Ministry of Health with a mix 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.
[13] https://www.oecd.org/science/addressing-societal-challenges-using-transdisciplinary-research-0ca0ca45-en.htm
[14] https://council.science/wp-content/uploads/2020/06/202108_Unleashing-Science_Final.pdf

co-chaired by the Rt. Hon. Ms. Helen Clark looking at how to prioritise global research in sustainability with a mission-led and transdisciplinary framing[15]. The work of that commission may have broader relevance to New Zealand's own considerations.

4. Research assessment

Research assessment is not considered in detail in the Green Paper but is at the heart of any research and science system. It ultimately determines who and what is funded and is thus part of prioritisation and the micro-scale. It, more than anything, provides the incentives that shape research outcomes. However, it is not always clear how the terms 'excellence', 'impact' and 'relevance' are gauged in research assessment. Much 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 (Mātauranga Māori research being an obvious exclusion).

As our assessment system also considers "impact" separately, it is therefore important that consultation considers what is meant by this. The UK Future Research Assessment Programme[16] is doing much work on the meaning of impact. This work and associated literature[17] including the report of the small, advanced economies initiative[18] and of the External Advisory Group on Health Research (New Zealand) point to the need to have a broad and accepted definition of impact. Any definition is certainly much broader than just economic impact which has dominated the narrative in recent years.

5. Māori research (section 2)

It is critical that all under-represented social groups are enabled to participate fully in the RSI system. It is undeniable that promoting EDI is an important factor for improving science in multiple ways. This matter also requires consideration of STEM education within schools. Further, there is a moral and constitutional obligation to address issues related to the current underrepresentation of Māori. It is also critical that priority is given to that research which addresses the challenges and concerns that Māori face. However, it is also important to

[15] https://stories.council.science/unleashing-science/
[16] https://www.ukri.org/news/launch-of-the-future-research-assessment-programme/
[17] For example Sivertsen G & Meijer I (2020) Normal versus extraordinary impact: how to understand, evaluate and improve research activities in their relationships to society. Research Evaluation 29 66-70
[18] https://www.smalladvancedeconomies.org/wp-content/uploads/SAEI_Impact-Framework_Feb_2015_Issue2.pdf

distinguish that role from that of protecting and exploring the Māori knowledge system both as a cultural taonga and as a epistemology and ontology.

The notion of science as *Western* science (the term is substantively misused in the Green Paper) is wrong. Rather there is a globally accepted definition of science[19] which is a global activity, and which originates from global inputs over centuries[20]. It always interacts with other knowledge systems in its application, including local and indigenous ways of knowing, and this intersection merits, research support.

Here there is a very important consideration. All cultural groups have empirical histories and belief systems, but those of Mātauranga Māori obviously have particular importance and resonance for Māori and thus for all New Zealanders. The unique knowledge has been acquired by Māori based on accumulated and sophisticated observation and this with other knowledge systems have always provided the seeds for subsequent enquiry using the approaches of the scientific methods. In turn science, especially through the medium of transdisciplinarity, can better engage with other knowledge systems including indigenous knowledge which in turn can provide knowledge that advances New Zealand.

Current discussion over the interactions between science and indigenous knowledge tend to conflate epistemological and ontological issues with issues of social justice and representation, for instance. Scholars of Mātauranga Māori need to be able to develop and share their knowledge, and it would benefit from a distinct funding stream.

Furthermore, how knowledge is used by society is a judgment involving multiple values. Māori, like all other New Zealanders, will want also to take advantage of the use of science. But it we all interpret scientific knowledge within our own worldviews, which are the product of our cultures and histories. Here is the danger of confusing matters. All New Zealanders are owed the opportunity to have a sufficient understanding of the scientific method and ontological foundation to engage with it and to make their judgements on how they use scientific understanding and incorporate it with their own identities and value systems (we have seen situations when this is not the case as reflected by the low vaccine uptake in parts of the community or in the climate change denial movement).

Transdisciplinary thinking is the emergent research approach to knowledge development and application that can engage multiple ontologies because the research engages multiple

[19] Sometimes the term global science or modern science is used but such descriptors are unnecessary. The International Science Council which represents both the natural and social sciences defines science as: *Science is a special form of knowledge; a formalised approach to knowledge that is rationally explicable, tested against reality, logic, and the scrutiny of peers*. For discussion see : https://council.science/wp-content/uploads/2020/06/ScienceAsAPublicGood-FINAL.pdf

[20] Indeed, the origins of the current scientific paradigm owe much to Arabic influences over 1000 years ago.

perspectives from the beginning[21]. The integration of Mātauranga Māori with science in a research setting is often best achieved via transdisciplinary techniques. Transdisciplinary research is in its infancy in New Zealand but needs to be extended more broadly (see below).

The structure of funding systems (section 3 and 5.3.2)

Administering research funding is not a trivial exercise but it is critical that this is separated from the policy process. This is no longer apparent in the case of the administration of MBIE funding. We have a complex and duplicative system with significant overhead costs. While some diversity in funding streams is valuable it should not be at the expense of *a r*obust system.

In 2010 FRST was absorbed into the Ministry reducing the separation of policy from independent assessment of research. It is also no longer apparent that the structure of Endeavour fund, SIFF (the science infrastructure fund), Marsden, HRC and various smaller amounts administered autonomously by NSCs amongst others has any inherent logic**.** The UK, for example, uses a model that reduces administrative overheads by using a single institution, the UK Research Institute, UKRI, then acts through seven disciplinary councils. Here the opportunity for sector coordination in research is paramount, allowing for prioritisation based on the types of programme, upstream and downstream research, and career development and diversity issues.

Extrapolating from the UK to the New Zealand context, it is possible to imagine that the Endeavour fund, the HRC, the funding from NSCs and COREs and perhaps the Marsden Fund could share a common infrastructure and back-office administrative entity supporting 8-9 research funding mechanisms as follows:

- Medical and health research,
- Social sciences,
- Humanities and creative sector,
- Environmental sciences,
- Biological, and natural sciences,
- Digital and technology.

With two or three additional panels:

- Mātauranga Māori,
- Transdisciplinary, and mission-led research.

The Marsden fund may also be a special case as it has a distinctive legitimacy with the academic community, especially early and mid-career researchers, and has been traditionally more isolated from the Ministry through the Royal Society Te Apārangi, but never-the-less could be integrated into this model as a panel.

[21] https://informedfutures.org/why-transdisciplinarity-matters/

Arguably the biggest constraint on New Zealand science is the ubiquity of the small tightly and constrained project grant. Global experience has shown that scientists often make their biggest breakthroughs on the margins of the funded activities. Hence, science in underfunded systems, inevitably becomes very conservative. This can be inhibitory, making it especially difficult for early career researchers to shine and show distinction as they get pulled in by the need to pursue a very conservative and generally predictable results. Current success rates in competitions which are budgetarily constrained pretend to distinguish the very best from those that are not funded. But the reality is that peer review in New Zealand is not sufficiently sensitive or objective to distinguish the highest quality proposals from others. Without more funding in the system, given the small size of the public science sector, we will continue to fund conservative research, impede career development and fail to advance important scientific activity. At the same time new modalities must be supported: data curation is now a much larger part of research costs; open science incurs other costs; transdisciplinary activity needs supporting; and career issues are obvious. All of these considerations come into prioritisation, and hence the need to have a transparent and high-quality process that both the science community and end-user stakeholders can appreciate and respect.

The mix of research across Pasteur's quadrants must be sustained and research assessment should be developed in ways that ensure that balance is sustained. Projects and outputs need to be assessed not only through classical measures of research output (most of which are quite misleading despite faith in bibliometrics) alongside socially robust methods of assessing impact and engagement. Research in each quadrant needs different assessment modes.

Transdisciplinarity

This is a gap in the Green Paper. This domain of research is increasingly promoted in global research policy circles and the OECD has highlighted that most major challenges and wicked problems are best addressed through research requiring transdisciplinary approaches. This type of research is a relatively new concept taking in some of the framings from what has been called ‘post normal’ science. It has two major characteristics. First, from the outset it frames the question through multiple perspectives and this process of framing also defines the methods of investigation. Often the disciplines involved extend well beyond a single knowledge system and certainly beyond a single epistemology. Secondly by definition, it must involve end users from the outset.

Transdisciplinary research thus takes time to do properly, and has a very different dimension to classical research approaches. For this reason, it requires distinctive assessment mechanisms and that extend beyond the individual project. Globally these methods are still evolving. Much of the NSC and CoRE research may already include some of this intent, albeit not constructed as such.

The New Zealand science system's progressive steps relating to Māori engagement often meet the characteristics of transdisciplinary research.

Social sciences

The taxpayer rightly wants knowledge it invests in to help build better lives. Obviously, this extends beyond direct economic outputs. Among other things, it is about using knowledge better to advise and inform the use of the c.70% of government expenditure which goes toward aspects such as health, welfare, justice, housing, poverty, education etc. Yet both directly and indirectly, social science research is very poorly funded and effectively discriminated against (excluding health) in the prevailing focus on the direct economic benefit of R&D. This is short-sighted; there is wasted opportunity to use research to improve the human condition in ways that potentially will reap dividends over time in areas of disadvantage, such as improving the social determinants of physical and mental health, social inclusion, etc. This country is one of few developed countries not giving priority to applied social research via engaging academia.

There are historical issues, but with us now in a data-rich age, surely it is time to get beyond the biases of both the social science community and of the policy community that have inhibited better use of social science in so much of policy making. The soon to be released ISC report on the long-term issues associated with the pandemic[22] highlight the importance of such science and the failure of many governments to properly incorporate it in framing their responses. In New Zealand the integrated data infrastructure (IDI) is an important tool which, because of its funding route, has yet to realise its full potential. When properly supported by ethical oversight and social license, this database is an important tool which offers extraordinary potential for advancing New Zealand social understanding.

Private sector research

The last decade has seen private sector innovation grow in New Zealand. There has been the emergence of 'angel' investment with multiple funds established. Whether changing economic conditions mean that we can rely on such gains into the future will depend on two factors; the funds available for investment and deal flow from R&D. For reasons of academic culture, deal flow in New Zealand has been relatively low from universities and CRIs. University entrepreneurial competitions have been a significant accelerant. The issues of IP beneficial ownership are different between CRIs and Universities and may create other negative incentives.

The extent to which Callaghan Innovation can take credit for the growth of entrepreneurial activity is unclear. Their scope of investment has generally not been associated with the most

[22] https://council.science/covid-19-scenarios/latest-updates/

obvious recent successes. Gradually more scientists are seeing their future in the private sector, but will they see such a future in New Zealand?

As mentioned earlier, there are real barriers in the nature of New Zealand companies which are largely the smallest class of SME. It will take time to change New Zealand corporate culture as globally facing entrepreneurship emerges to displace the currently very narrow domestic focus. Internationally, it is recognised that it is large companies that create the innovation ecosystem and there is great competition amongst cities globally to attract the R&D centers of large companies. New Zealand has not really been on this map although it has some attraction as being a safe, environmentally interesting, and friendly country in which to locate research staff. It is also regarded as free of corruption and an easy place to do business. But the large international companies also need an assured trained and educated workforce. As a result, unless the training output grows in areas such as the digital space, this will remain an impediment. Even the most successful companies such as Apple and the other digital giants creating their presence in Auckland, are very concerned about the lack of depth in the skilled workforce. There are also concerns about inhibitions and barriers to migration that are now rate-limiting. Thus, other policy levers are needed if the sector is to leverage optimally off science and technology investments that the Crown makes.

The Apple example highlights another point – Apple is research active in New Zealand because 30 years ago University of Auckland scientists developed an induction-charging methodology which, in the hands of successive science generations, led eventually to the wireless charging technology Apple now uses in a number of its devices. Because of this and the key players remaining here, Apple has one of its most significant research bases located in this country.

Attracting multinationals is important, but equally we must work harder to retain companies that start here. LanzaTech was a major loss to our ecosystem and is now a billion-dollar unicorn with no New Zealand footprint. The reason for its departure was in part related to the regulatory framework around genetic technologies in New Zealand. This is an ongoing issue that harms New Zealand science and its potential. Rocket Lab, even if largely offshore owned, still has a significant presence in this country and as such is of extraordinary value in building a science and technology ecosystem around it. Countries such as Israel have developed ways to incentivise locally developed R&D to stay locally-based even if the company goes global. As our innovation sector grows, such devices will be important of the developing ecosystem.

The workforce (section 5)

Science is ultimately carried out by talented individuals increasingly working in teams. Clearly those teams and the workforce must reflect the diversity of our population. But the system is not

coherent in marked contrast to where it used to be[23]. Because of tight funding, no young scientist can bet their family and future on capricious contestable funding. Further the system does not identify talented people at the correct stage so as to help them to advance through the system. Universities are also much at fault here; they can grind down young academics. The system also takes advantage of full-time researchers funded by research grants, seeing them as sources of reputation, of indirect income and casual teaching rather than committing to pathways of integration and stability. This contrasts strongly with systems in many northern hemisphere countries. It is very expensive to train young scientists and they are a resource not to be squandered, yet grant failure and loss is too common.

The CRIs do not have workforce development as a core obligation and their relative separation from the universities is disadvantageous to all parties. However, not every young graduate should have a future in publicly funded research. There is a higher percentage of PhDs in New Zealand within academia and publicly funded research than elsewhere in the OECD and we need to see increased flow into policy practice, and private sector research. The training of PhD students should increasingly focus on career development with that in mind. Postdoctoral fellowship training is important but not every graduate should axiomatically have such training. Hence investments in postgraduate training should also include career mentorship rather than perpetuate unrealistic expectations that all will have academic research careers.

The size of the research funding pool in New Zealand is small, given the size of the Higher Education sector and the workforce issues cannot be addressed well without looking at the overall shape of the system. This is a further reason for considering the merger of higher education and a research ministry. The current serious dislocation inhibits an understanding of needs for the country that can be best addressed by more comprehensive workforce planning and integration by the two relevant ministries. Again, looking overseas to Canada and Europe highlights mechanisms that might be more appropriate.

International relations, science diplomacy

If there is one single priority, it may be to greatly strengthen New Zealand's international engagement in science. While individual scientists may be well-connected, less could be said about the system as whole, and its importance is underappreciated.

New Zealand is geographically isolated and, in many ways, also geo-strategically. It is an advanced country yet not part of G20. However, science is very much a global activity and there are few if any domains of science that do not depend on such connectivity. By global standards the size of the New Zealand science community is minute and while in places, there is outstanding work, we

[23] My own career was entirely built on an integrated research career support pathway in the 1970s-1990s which has now gone; overseas research fellowship, repatriation fellowship, senior research fellowship, career research fellowship of the Medical Research Council replaced in 1992 by the Health Research Council.

need to work hard to be a meaningful part of the global science community. In general, the universities have taken some initiatives here in supporting staff interchange and travel, but this must be framed by a much more strategic and nationally coherent approach.

New Zealand does not consistently invest in science diplomacy or international science in a strategic way. In my experience there were sharp divisions between MFAT and MBIE over international science, its purpose and the opportunities it brings for the country. Most of the small budget that could be ascribed as international science has been boiled down to specific and narrow bilateral agreements. Thus, the quickest way to enhance the reputation and impact of New Zealand science would be to significantly enhance and open up international science funding. Many New Zealand scientists have been offered chances to be significant players in international research programmes provided they can contribute funding, but domestic funding mechanisms are still not responsive enough to be part of it.

It is a hopeful green shoot that we are now in discussions to be an associate member of the European Research Area.

When I acted as science envoy for MFAT from 2014-2018, most advanced countries were investing significantly in science diplomacy, whereas there is now essentially no such presence within MFAT. Parenthetically there are many scientific and technological challenges ahead which MFAT will have to confront.

Government agency research

The ongoing failure of the government to recognise and organise its own research for its own needs is of continuing concern. The External Advisory Group on Health Research pointed out the very low expenditure for example by the Ministry of Health on operational research. This is c.10% in relative terms of what the UK spends. The same is true in many other areas. The Green Paper review would be greatly enhanced by extending the scope to consider government departments' own use of R&D, their low engagement with the university sector and the low rate of interchange between policy and academia etc.

Part C Towards a possible and significant reform

The dimensions of the discussion above point to one core recommendation:

That a single new ministry, giving oversight of public research, and universities should be established to set policy in science, research, and higher education. It should be distinct from MBIE and the Ministry of Education.

Such a model is common overseas. How this might operate would need much more substantive work, but the suggestions below incorporate both the specific ministry recommendation and the welter of considerations discussed above. These suggestions are intended as a provocation rather than as a formal recommendation.

The TEC could remain now as the audit and performance manager of universities ensuring linkages to the other components of the tertiary sector and continue to administer the PBRF, which itself needs significant review. The CRIs could be formed into a single entity (excluding Callaghan innovation).

A national research funding entity should be established of similar scope to UKRI and described in this paper as the New Zealand Research Council (NZRC). This agency, NZRC, would set research operational policies and administer research through several research boards with appropriate expert and esteemed members. One of these boards would be for health research equivalent to the HRC. The other boards would be created for humanities and creative arts, social sciences, natural sciences and Mātauranga Māori research respectively. The NZRI would approve each body's research plan encompassing short term and long research and career development. The NZRI would also establish a board to support transdisciplinary and mission-led research. Preferably the Marsden Fund would be a further council operating under the aegis of the NZRI

Consideration is needed as to the implications of moving away from the full cost model by separating out the capital component.

The NZRC would be expected to take responsibility for rigorous review mechanisms for each funding domain and tool as well as for decisions independent of the political process, based on clear prioritisation and evaluation. Its role would include science system advice and setting priorities and developing decadal research road maps for each sector while ensuring that there was always at least 60% of funds available for investigator-led research. In this way, research prioritisation will not be allowed to constrain the potential innovative capacity of scientists.

Critically therefore, this model allows for transparency around funding shifts in alignment with government high level RSI strategic thinking and priority-setting, as well as providing coherence to managing the evolving state and contribution of science.

Appendix

An edited extract from the External Advisory Committee on Health Research to the Ministries of Health and Business, Innovation and Employment 2019 on justifications for " why fund health research in New Zealand'.

Priorities might include;

- Work based on areas where New Zealand has distinct expertise (e.g. some areas of biomedical science, cohort studies) or advantage (e.g. use of the IDI).
- Work where the work is of distinct relevance with respect to our particular populations (i.e. Māori health, Pasifika health, migrant health). However, the latter should not be used as an excuse for confirmatory research simply repeating work done offshore.
- Work on health services delivery because of New Zealand's unique health system, population characteristics and significant public investment in the health and disability system (and ACC).
- Research that enables a better understanding of New Zealand's diverse population and social contexts; and the development of relevant policy, services and treatments that achieve greater health equity.
- Research that creates opportunities to gain in Māori health research and a need to advance Pacific health research and consider other groups of peoples such as migrants and refugees.
- Research that raises the efficiency and effectiveness of the delivery of a wide range of government services in the health, social, justice, environment and biosecurity sectors.
- Research that contributes to innovation for economic gain through commercialisation of research and innovation.
- Research that generates spill-over benefits to the primary industries and the environment.
- Research that raises New Zealand's capacity to absorb and adopt knowledge and technologies from offshore.
- Research that benefits small Pacific islands which have a direct bearing on New Zealand's resident population.
- Research that builds international standing and credibility – inherent value of research for a small advanced economy.
- Research that helps with recruitment and retention of top health professionals.