Science System Advisory Group Report

An architecture for the future

August 2024

Science System Advisory Group

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The Science System Advisory Group (SSAG) was established by the Ministry of Business, Innovation and Employment (MBIE) in March 2024 to provide advice to the Government on strengthening the science, innovation and technology system. Group members will consider challenges and aspirations of the many components of the sector, and its structure, efficiency and effectiveness.

Science is used in the broadest context to include all the robust knowledge systems in accord with UNESCO and International Science Council definitions – this encompasses the natural, social, health, technological and data sciences and those related humanities focused on developing reliable understandings of the observable world. The use of the term 'research' is intended to include the humanities and creative disciplines.

This document is the first of two reports. It focuses on determining principles for the sector moving ahead and on providing preliminary advice and recommendations.

The second report will provide further recommendations and advice on longer-term changes to ensure the future success of the science system in New Zealand.

Authors

Sir Peter Gluckman (Chair), Michael Ahie, Prof Mark Ferguson, Dr Hermann Hauser, Dr Barb Hayden, Nadia Levin, Prof Tracey McIntosh, Dr William Rolleston, Distinguished Prof Hamish Spencer, Prof Alastair MacCormick (University Advisory Group (UAG) observer), Hema Sridhar (Project lead).

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Preamble

On March 25, 2024, Cabinet approved terms of reference for the Science System Advisory Group (SSAG) requesting it to consider all components of the research and innovation system. In doing so it noted that:

"Our public research system, Crown Research Institutes and universities, face enduring structural challenges that get in the way of it delivering value to New Zealand. The system is fragmented, with poor visibility of the effectiveness of current investments, and suffers from duplication, inefficiency, and poor use of resources".

"The extent of the problems identified within both systems means that it would be surprising if the advisory groups did not recommend fundamental change".

The terms of reference requested an interim report by June 2024 and consent was given to extend this to July. In alignment with the work plan agreed with the Ministry of Business, Innovation and Employment (MBIE) and the minister, Hon Judith Collins KC, we have focused our consultations and panel discussions to date on structural and related issues, deferring other and more technical aspects to our second report due later in 2024, the foci of which will be influenced by advice from Government in relation to the present report. However, we are confident that nothing in the second report will alter the structural and related recommendations made here, allowing the Government, should it accept our recommendations, to proceed with a number of steps in the immediate future.

The SSAG has conducted extensive consultation, with discussions and presentations across all universities and Crown Research Institutes (CRIs) involving over 7500 individual attendees, CRI boards, vice chancellors, Callaghan Innovation, New Zealand Trade and Enterprise (NZTE), officials across multiple ministries and agencies, and a wide variety of private sector interests including small companies, large companies, high-tech companies, venture capital firms, the chairs of previous reviews into the science system, etc. and received more than 300 written submissions. In addition, the SSAG has consulted domestically with many officials and internationally with science and innovation system experts and senior officials in Singapore, Denmark, Israel, UK, Ireland and the OECD. The SSAG has met online fortnightly and developed this report over a four-day in-person meeting in June 2024.

Given the urgency of the need to progress some of the matters under consideration, two components of this report (recommendations and an expanded executive summary) were provided to the Minister in advance of the full text of this report.

The SSAG wishes to note the significant and constructive help given by officials in MBIE.

Sir Peter Gluckman
Chair
Science System Advisory Group
August 2024

Contents

Recommendations

General recommendations

1. Note that the SSAG's work has been primarily driven by consideration of how the science and innovation system can better contribute to New Zealand's economic and broader development. The changes recommended are driven by these strategic imperatives, not simply by operational considerations.
2. Note that the SSAG has consulted extensively across the public and private sectors, that this report focuses on identified issues in the current architecture, and that it suggests the future architecture of the science, innovation and technology system needed to promote New Zealand's productivity and broader social, environmental and economic future. A future report will focus on other aspects and operational detail.
3. Note the global evidence is robust that science and technology are core to enhancing productivity in developed economies, including in small, advanced countries, many of which are now committing to increased investments in this sector.
4. Note that rapidly evolving science and technological developments are having broad impacts on geostrategic, security and trade relationships, and are impacting on national economic strategies across the developed world.
5. Acknowledge that New Zealand must more urgently employ research, science and technology systematically and effectively, along with the consequential innovation pathway, to better address its economic, social and strategic challenges. We are at a critical inflection point in New Zealand's direction and future as a developed country in a rapidly advancing technological world. This requires reprioritisation and both system and attitudinal change.
6. Note that rapid advances in science and transformations in technology are altering economic and power relationships, and that these changes generate risk, opportunities and challenges for New Zealand.
7. Note the overwhelming evidence that investment in research and science is absolutely core to productivity growth. Failure over several decades to accept and act on this causation has led to New Zealand being a poorly performing outlier compared to most advanced economies, notably those of comparable size. Continued underinvestment will continue to compromise New Zealand's future.
8. Seek bipartisan support for a long-term commitment to an adequate and effective research and development investment.
9. Acknowledge that the research, science and innovation system, including the higher education component, needs to be more strategically aligned and will need to be redesigned for greater effectiveness, efficiency, responsiveness and agility.
10. Develop a high-level action plan to redesign the architecture of the research, science and innovation system with a clear timetable for delivery over the next 30 months, while minimising disruption to the system. Several changes to progress the process can be achieved during 2024.
11. Recognise the need for international partnerships in research, science, technology and innovation given New Zealand's population and geography, its geostrategic and security needs, and its economic, social and environmental challenges.

12. Note that public research and science, including the social sciences and humanities, have multiple roles in enhancing our country's wellbeing, including providing the knowledge and understanding to support the stewardship of New Zealand's social, environmental and economic assets, informing policy formation, supporting knowledge generation (including that distinctive to New Zealand), and in generating and supporting innovative ideas that can flow into the private sector.
13. Note that mātauranga Māori can make a unique contribution and broaden the impact of research delivery for all of New Zealand.
14. Note that as a small country, New Zealand cannot do everything in research and science, and therefore must make strategic choices that will advantage it in a knowledge-intensive world.

Specific recommendations

15. Establish a Prime Minister's Science, Technology and Innovation Advisory Council (PMSTIAC). One role of the PMSTIAC is to assist the Government in ensuring a long-term direction and strategy for the research, science and innovation system. It has the further role of ensuring a more integrated whole-of-government approach to science and innovation and its use.
16. Redefine and expand the role of the Prime Minister's Chief Science Advisor (PMCSA) to support PMSTIAC and to enhance the use of science and technology across Government.
17. Establish a separate and focused Ministry for Science, Innovation and Technology that reports to a single minister who has commensurate decision-making capacity and influence to leverage and safeguard the success of the science and innovation system into the future.
18. Consider mechanisms by which the university component of the Ministry of Education might be better integrated with the science, innovation and technology (SI&T) component (currently residing within the Ministry of Business, Innovation and Enterprise); for example, by transitioning it into this new ministry, supported by a Higher Education Council with a strategic and coordinating role over the university system.
19. Agree with the proposed new components of the science system under the aegis of the new Ministry, which include the establishment of a National Research Council (NRC), a National Innovation Advisory Committee (NIAC) and a Research Infrastructure Advisory Committee (RIAC).
20. Establish a National Research Council (NRC) combining mission-led and contestable research funding mechanisms operated by the Crown (including Strategic Science Investment Fund (SSIF), Endeavour, Marsden and Health Research Council (HRC) mechanisms). The NRC will operate through distinct expert-assessed pillars, including one to support mātauranga Māori.
21. Establish a National Innovation Advisory Committee (NIAC) and two agencies: Innovation New Zealand (INZ) and Enterprise New Zealand (ENZ).
    a. NIAC would advise the minister on support of outward-facing and domestic-facing activities through INZ and ENZ, respectively, and be responsible for strategic oversight, evaluation and direction of the innovation pipeline.
    b. INZ would focus on outward- and global-facing innovation functions that are underserved at present and include attracting R&D activity of multinational corporations and foreign direct investment and creating a single point of entry for inward investment. It would address current gaps as well as incorporating those related and relevant outward activities currently overseen by New Zealand Trade and Enterprise (NZTE) and Callaghan Innovation.

c. ENZ would focus on start-up and scale-up of New Zealand companies, integrating activities currently set in Callaghan Innovation, NZTE and MBIE, including incubators, mentorship services, pre-seed and seed funds, and industry grants, and create a needed single-entry point for New Zealand companies.

22. Establish an action plan to transition from the existing CRIs to a new entity (provisionally Public Research Organisation NZ, PRONZ), with a single board and with high-quality administration with strong scientific management. The formation of the PRONZ will be strategically planned and phased over several years to have a robust transition, providing certainty and minimising disruption to CRI staff and capability while focusing on ensuring scientific capacities in a more adaptable and efficient framework to meet New Zealand's current and future needs.
23. Establish a Futures Technology Initiative (FTI) to support public, private and joint initiatives to build an agile, multidisciplinary workforce, address the social issues of rapidly developing technologies, develop public and commercially focused initiatives, and diffuse knowledge and capabilities to New Zealand businesses.
24. Disestablish Callaghan Innovation, redistributing valued activities to either Innovation New Zealand (INZ) or Enterprise New Zealand (ENZ) and to the merged Public Research Organisation (PRONZ).
25. Establish a singular set of rules for Technology Transfer Organisations (TTOs) that applies across the entire science system including universities and CRIs. This harmonisation must address issues of unrealistic valuations, high equity retention, focus on promoting the invention, and to reflect that publicly funded science is for the benefit of New Zealand.
26. Note the critical importance of the science and innovation workforce, and that actions will be needed at multiple levels to develop and retain a high calibre workforce of researchers, scientists, innovators and entrepreneurs, noting that our changing demographics will significantly affect the profile of future generations of students and scholars, and this will need to be taken into account.
27. Invest in and develop a targeted plan to attract and recruit high calibre talent and leadership in both the public and private sectors and remove the barriers that inhibit this attraction.
28. Develop a whole-of-government policy for data collection, curation, analysis and use, including that based on artificial intelligence (AI).
29. Recognise the importance of attracting multinational corporations to undertake research and development in New Zealand and the essential value of foreign direct investment (FDI).
30. Consider the acceleration possible to the innovation economy if major Crown-associated investment funds such as the NZ Super Fund invested a small fraction of their portfolio in New Zealand-based companies through professional innovation funders that focus on this sector, such as NZ Growth Capital Partners (NZGCP).
31. Note that the recommended changes require careful management over time and programmed over several prioritised steps.

Executive summary

1. Researchers, scientists, innovators and entrepreneurs across New Zealand offer enormous and significantly unrealised potential to lift New Zealand from its productivity malaise. That potential has a critical role to play in producing the vibrant diverse economy that is desperately needed to address the many societal and environmental issues that threaten our capacity to be the ambitious, healthy, productive and cohesive advanced society that every New Zealander, irrespective of partisan identity, desires. However, the sad and concerning reality is that New Zealand is at a critical decision point: there are a set of issues that require immediate action if research, science and technology are to meet their promise and play their unique and essential role in our future.
2. The rapid emergence of advanced technologies including artificial intelligence (AI), quantum technology and synthetic biology will have enormous implications for where trade and economic growth will occur. It will impact geostrategic relationships. These technologies will improve the ability of governments to make better decisions, serve their core obligations, and steward the human, environmental and economic assets of a country, and for businesses to be more productive and to directly and indirectly improve our wellbeing. New Zealand is simply not prepared and given the pace of change will soon struggle to stay respected as a first world nation.
3. The SSAG notes that science and innovation are one of the five strategies that the current Government has identified as part of its economic objectives. However, it also notes that the current settings in the science, innovation and technology (SI&T) system make that ambition unrealistic without significant, rapid and integrated change as suggested in this report.
4. For reasons based in our cultural mythology ('number 8 wire', 'we punch above our weight', etc.) and selective interpretation by officials across core agencies over many years, New Zealand is an outlier in its attitude to science. Every other small, advanced country and most major countries, as well as the European Union, have long recognised and demonstrated the core role of SI&T in advancing productivity. Indeed, the international consensus is that investing in SI&T is now the core element to productivity enhancement. SI&T also addresses many of the needs in environmental and societal areas and improves the effectiveness of government. Most countries of our type are now setting more ambitious goals for SI&T investment despite difficult economic times.
5. But New Zealand has for too long chosen a different path and has seen its relative wealth and position decline, content to live off past R&D investments in the primary sector. Indeed, Treasury analysis suggested that investment in SI&T by New Zealand in that sector between 1927 and 2001 had an annualised 17% rate of return.[1] However, given today's world and our place in the global economy, we must diversify and recognise the broad set of challenges that must be addressed. While much talk is made of the private sector needing to invest, public investments must also significantly increase. The base capacity in the public sector and the low levels of public investment limit ideas flow and innovation that evidence shows drives private sector responses. The global evidence is overwhelming in terms of the critical need for greater public investment to ensure stronger private sector investment.
6. Our SI&T system is complex, bureaucratic and full of practical barriers which undermine its effectiveness.
7. The entire SI&T system, including the university sector, suffers from a lack of long-term strategic visioning and oversight.

1 New Zealand Treasury. (2018). The Role of R&D in Productivity Growth: The Case of Agriculture in New Zealand: 1927 to 2001. *New Zealand Treasury Working Paper 06/01*. https://www.treasury.govt.nz/sites/default/files/2007-09/twp06-01.pdf

8. The Cabinet paper of 25 March 2024 suggested that fundamental architectural change is needed across the whole SI&T system. Our recommendations should not be seen as a smorgasbord: to have an effective and productive system, changes in the SI&T system must be managed as a set. Change for change's sake is wasteful, disruptive and unacceptable. The SSAG has considered the options carefully and concludes that minor adjustments, which have been the dominant approach since the system was revised in 1991, cannot succeed any longer. But it is important that change management is done in a way that protects the core human and intellectual assets that underpin the system.
9. The SSAG recommends a simpler and more effective SI&T system architecture that has the following goals:
    a. A strategic approach to ensure and oversee a more effective and highly productive public science system.
    b. Obviating the unnecessary bureaucracy, duplication, excessive management and lack of expert practitioner-led decision-making that characterises the current SI&T system.
    c. Reducing the complexity and challenges of the current innovation system and addressing the gaps that limit its potential.
    d. Recognising that public investment in R&D has multiple overlapping functions that together directly and indirectly drive productivity:
        i. Providing the knowledge and understandings that allow more effective stewardship of the country's social, natural and economic resources, and address the complex challenges such as climate change, sociological changes and a more diversified economy that the Cabinet paper identified.
        ii. Providing the information and understandings that allow the Government and its agencies to make more effective decisions and support policy development.
        iii. Ensuring the generation of new knowledge for both public and private good, and for an understanding of the unique aspects of our society, heritage, environment and geography.
        iv. Fuelling an increased flow of knowledge, information and technology to the private sector to promote an innovation-based and more diversified economy.
    d. We would expect to see a more diverse workforce including greater Māori leadership, workforce, interests and aspirations across the SI&T system.
    e. In making change, decisions must be made with cognisance that we are a small country which cannot do everything possible in SI&T. Choices need to be made, and strategically defined international and domestic partnerships in both science and innovation need to be enhanced.
10. This initial report does not address consequential operational matters, nor the critical roles of science and research in supporting policymaking and in ensuring stewardship of our society, culture or environment. These matters will be addressed in the second report.

Core elements of a proposed new architecture

11. Figures 1 and 2 below illustrate the current and proposed architecture of the system. As requested by Cabinet, simplification, barrier reduction and strategic alignment have driven the shape of the recommended architecture.

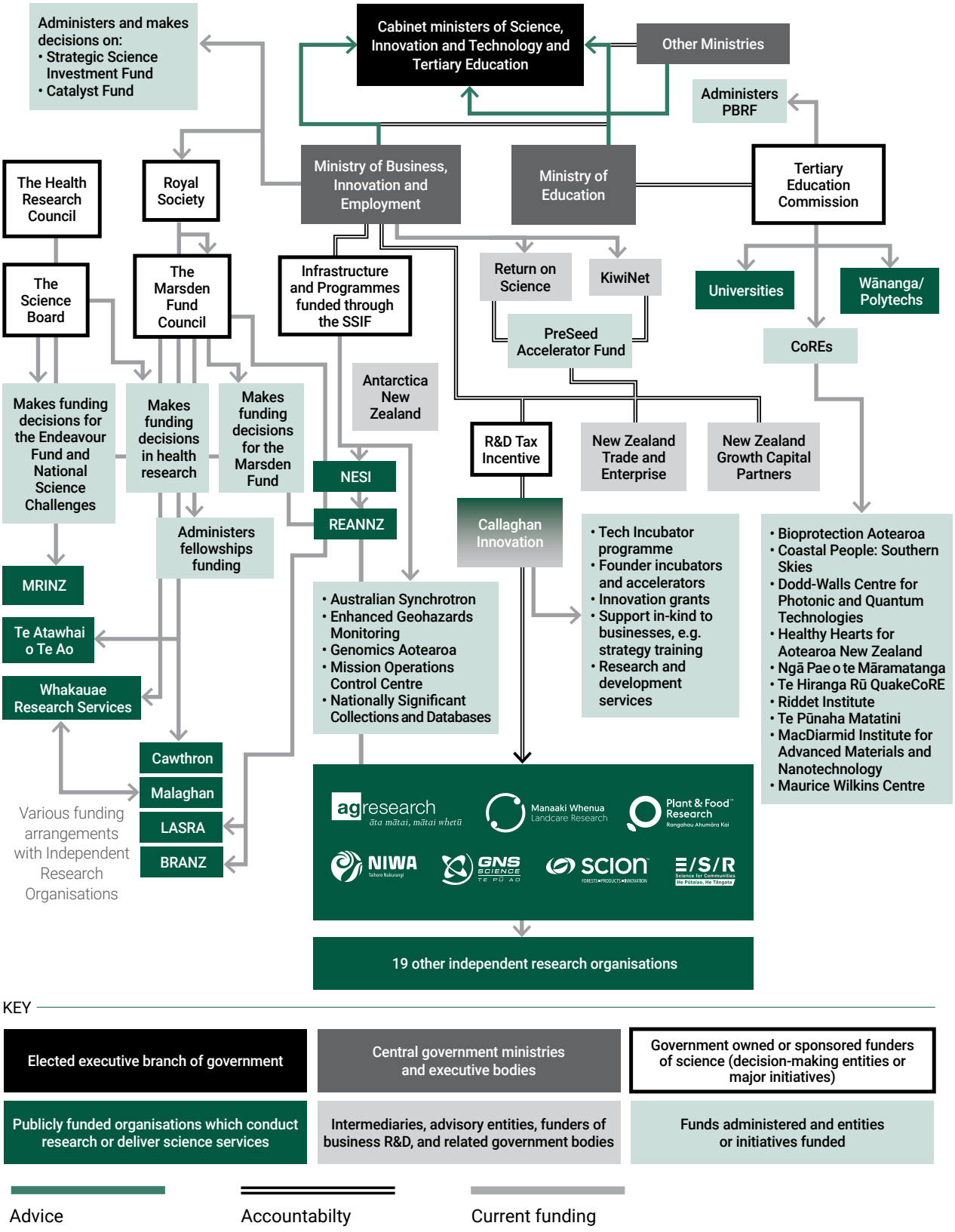

Figure 1: Current Science, Innovation and Technology System.

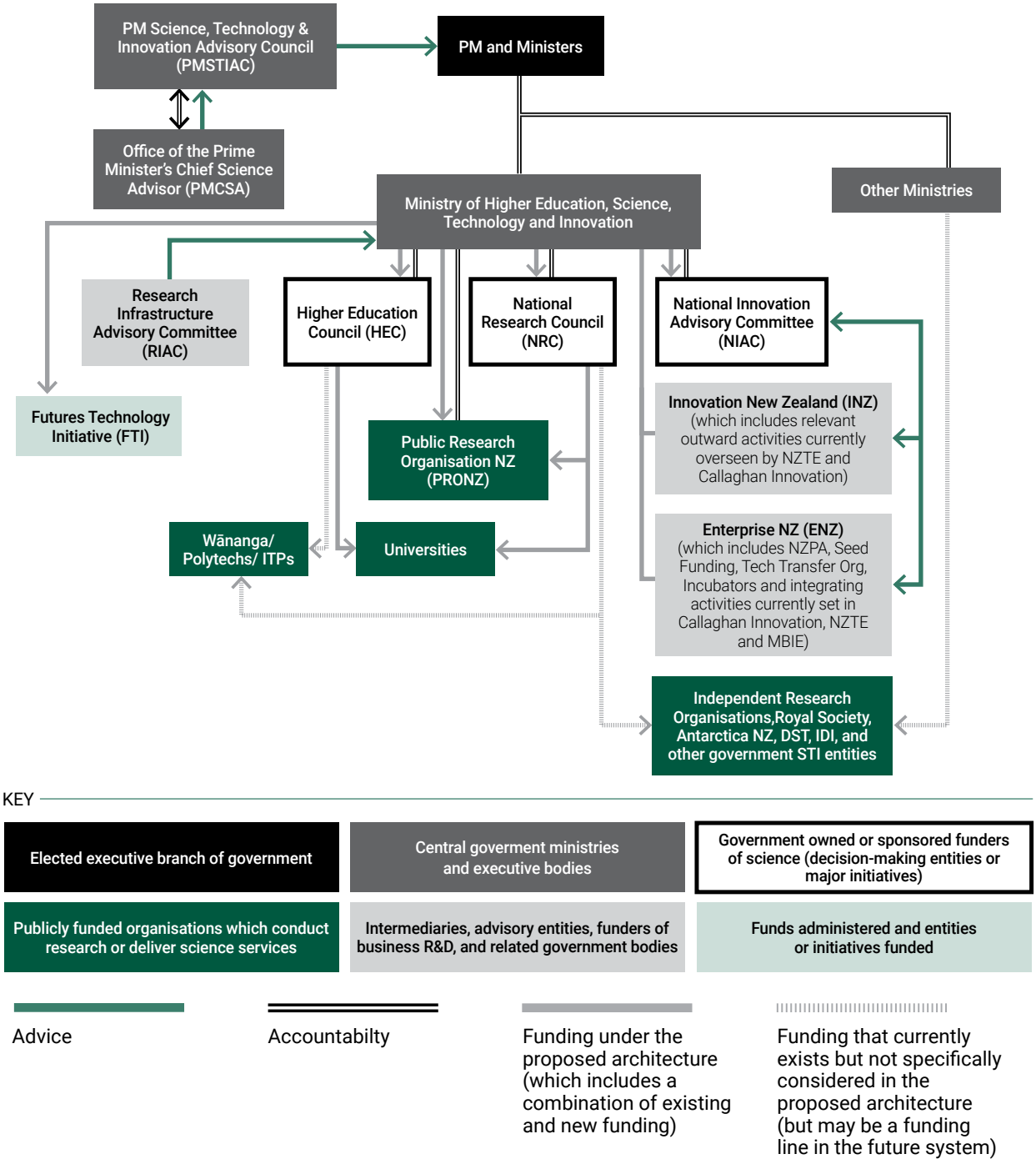

Figure 2: Proposed Higher Education, Science, Innovation and Technology System – High Level Architecture.[2]

2 Note that further detail on the interaction with other parts of government and the subsidiary activities of the four bodies will be detailed further in the body of the text of the full report.

12. **Prime Minister's Science Technology and Innovation Advisory Council (PMSTIAC).** New Zealand is remiss in not having an overarching whole-of-government view of science and innovation and their contributions to the full range of government strategy-setting and societal decision-making. Science and innovation are core to a nation's economic development and its social, environmental and security strategies. In a small country, choices need to be made and integrated with many other aspects of policy. All other small, advanced nations understand this and make SI&T an essential and central part of economic strategy. The Prime Minister, as the individual responsible for coordinating the whole-of-government strategy, convenes in many countries such an advisory board/council comprising senior ministers (science, finance) along with business, scientific and academic leaders. As SI&T increasingly overlaps with geostrategic and security/defence considerations as well as economic ones, and given the pace of technological change, the need for such a council is palpable.

13. **Science advisory system.** It is suggested that the role of the Prime Minister's Chief Science Advisor (PMCSA) be revised and extended to be the executive officer of the PMSTIAC; this situation is analogous to that in countries such as the UK and USA. The other core roles of the PMCSA would be to assist the Prime Minister as appropriate, particularly in emergencies/crises, and to enhance the efficacy of the use of science across Government, including via a departmental science advisory mechanism (which needs to be refined and clarified as to its purpose and established more consistently in agencies).

14. **A new integrated and focused ministry.** One of the most obvious barriers to a more productive SI&T system is the gulf between the two major components of the public research provider system, the universities and public research organisations (PROs). They report to different ministries, and this creates multiple policy and functional barriers between themselves and in turn between them and the private sector; these became obvious in this review. The higher education system itself is a major provider of research across all disciplines and is a significant funder of research through the Centres of Research Excellence (CoRE) scheme and elements of the Performance-based Research Fund (PBRF). These functions, along with consideration of workforce needs, need to be integrated better with activities currently funded by MBIE. How this is best achieved needs further consideration. For example, many other advanced countries (including virtually all in Europe) have brought these two policy agencies together in a single ministry. There may be other options that could be developed to achieve similar objectives.

    The new ministry would provide strategic oversight on workforce development; knowledge production and exploitation; and foresight, oversight, integration and coordination of a proposed set of four subsidiary councils/committees. While the final shape of the proposed ministry might have to await resolution of the shape of the polytechnic sector, matters involving the universities could be addressed once the University Advisory Group (UAG) has also considered this matter.

    Beyond its policy and foresight roles, the Ministry would receive advice from both PMSTIAC and from the bodies it would have responsibility for, which are:

    - A National Research Council (NRC)
    - A Higher Education Council (HEC) (subject to decisions about the positioning of the university sector)
    - A Research Infrastructure Advisory Committee (RIAC)
    - A National Innovation Advisory Committee (NIAC), which will coordinate between:
        - Innovation New Zealand (INZ)
        - Enterprise New Zealand (ENZ)

These organisations must be largely expert-led, well-coordinated with each other through cross-representation, and with the strategies set by PMSTIAC and the Ministry.

The new Ministry should oversee the reorganisation of CRIs into a single Public Research Organisation (provisionally called PRONZ) and the development of a Futures Technology Initiative (FTI); both are discussed below. A future-focused science and innovation system, as well as national security and economic and social development, depend on good foresight. Technology foresight is currently very weak in the New Zealand system. Given that the current Minister of Science, Innovation and Technology is also Minister of Digitising Government, Space, Intelligence Agencies and Defence, this moment is an opportune time to address this deficit.

15. **National Research Council (NRC).** New Zealand has many agencies, and parts of MBIE and other ministries administer funds supporting both contestable and/or mission-led research. By international standards each of these funds are small. Their size creates problems of oversight, process, grant funder shopping, committee bias and many other inefficiencies. There is no reason why they cannot be combined to ensure greater alignment with national need and priorities, as is the case in many countries. This will require further consultation. The SSIF, Endeavour Fund, Marsden Fund and the Health Research Council could be integrated within a single high-level oversight board, the NRC, with members representing Government, research and end-user communities. The NRC would need as CEO a highly respected scientist/administrator who can link with stakeholders. The NRC would oversee expert panels linked to pillars including technological, life, natural, social and health sciences, the humanities and creative arts. The principles of peer review must be maintained, but where possible international input is essential. The next report will discuss the NRC's broader role in supporting platforms and large-scale mission-led and transdisciplinary research, along with other forms of contestable and non-contestable research funding. Mātauranga Māori is New Zealand's distinct Indigenous local knowledge system. It merits research and should be a distinct pillar within the NRC. Decisions on funding should be made on three criteria: links to the priority settings set by the Crown, excellence, and why the specific research proposed is a priority investment in a country of limited resources and only five million people.

16. **Universities:** Our eight universities are an absolutely central component of the research, science and innovation system. Yet they are poorly integrated into a strategic approach to the entire SI&T sector. We received much commentary on the failure of them and the CRIs to act as a system. There are many barriers between universities and other components of the SI&T system which impede the overall system's effectiveness. Generally, the university sector has been given less attention in previous analyses of the SI&T system. The cabinet paper establishing this review and the parallel UAG review is the first significant attempt in decades to look at the system as a whole. There has been a much communication between the two reviews with reciprocal observers. The need for more seamless strategic integration and linkage between these two components of the SI&T system is seen by both as a priority.

    Universities have many functions, but all directly impact on the broader roles of the SI&T system; they are key to providing the future workforce, and they produce many of the ideas that can transition to impact through transfer to the policy community and particularly to business. They are the primary source of social sciences and humanities research in New Zealand, which are critical for much public policy development. The universities employ the country's largest concentration of researchers and scientists. They have the central role in addressing the imbalances in the demography of our graduate workforce. Duplication with the CRI sector is obvious in places, and even where there is colocation of CRIs and universities, the opportunities are not optimised.

17. **Higher Education Council (HEC).** The university system taken as a whole is largely devoid of strategic oversight and long-term planning, leading to many issues including the failure to consider the value of greater differentiation; these issues are being addressed to the parallel UAG review. The SSAG has consequentially concluded that the current model – the Ministry of Education providing policy while the Tertiary Education Commission (TEC) provides oversight and ensures compliance – is less than optimal for a knowledge and innovation-based economy. The lack of strategic direction and strategy in the university sector is obvious and acknowledged by officials. A more integrated and differentiated university sector with reduced barriers between it, the public research system and business is needed. The UAG agrees that much greater strategic oversight of the university system is needed.

18. **Research Infrastructure Advisory Committee (RIAC).** Research infrastructure is expensive but essential. Over the last decade, CRIs and universities have collaborated on the provision of equipment for high-performance computing, research, data management, training and connectivity. These capabilities underpin New Zealand's aspirations across virtually all research domains (including, notably, AI). But beyond this partnership, which is now fraying, the current incentives create institutional self-interest that hinders an optimally collaborative research ecosystem in our universities and CRIs. This leads to duplication and underuse of equipment. With the need for quantum computing capabilities to soon emerge, along with data centres and other critical infrastructure, a more coordinated approach to planning and purchasing seems necessary. The RIAC could take on this role which would allow more effective use of expensive assets and increased capacity available to both the public and private sector, and it would address the issues associated with prohibitive overheads. The Ministry should have a cross-sectoral advisory mechanism appropriate to manage the purchase of expensive equipment which might (say) range in value between $1 million and $50 million (e.g. a research vessel, supercomputer or quantum computer). The Government should seize an early opportunity to combine existing vehicles (e.g. supercomputers, NESI, REANNZ[3]) and capabilities into a single Data and Digital Research Platform to grow the uptake and level of sophistication of digitally enabled research in New Zealand. This would be a priority task for the Ministry and RIAC to consider.

19. **National Innovation Advisory Committee (NIAC).** Working under the general direction of the PMSTIAC and Ministry, the NIAC would advise the Ministry on the evolving needs of the innovation system and coordinate several functions that are currently spread, unfocused or missing. It would require high-quality expert membership to be able to advise the Minister on support of outward-facing and domestic-facing activities through two agencies, **Enterprise New Zealand** and **Innovation New Zealand.**[4] NIAC's membership would include the chairs and CEOs of these two agencies as well as a member of PMSTIAC and appropriate innovation leaders. The NIAC would be responsible for strategic oversight, evaluation and direction for the innovation pipeline.

20. **Innovation New Zealand (INZ).** This new external-facing agency would have functions currently seen to be largely absent or poorly served within the overall system, focused on attracting foreign direct investment (FDI), including venture capital and multinational corporations (MNCs). This would involve transferring some current elements of NZTE and Callaghan Innovation into it. Nothing in this report is intended to comment on the rest of NZTE's activities. To ensure coordination, the NZTE board chair should be a member of the INZ board.

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3 NESI is the New Zealand eScience Infrastructure; REANNZ is the Research Education Advanced Network New Zealand. The panel supports the intent of MBIE to merge REANNZ and NESI into a single entity as a logical initial move.

4 The panel also considered whether INZ and ENZ should be a single organisation or even whether they should be merged with NZTE, but their core outward and inwards facing roles respectively are very different. They require different relationships, skillsets and expert advice, which the panel concluded strongly supported distinct entities, albeit interacting closely via NIAC. International advice was also strongly of the view to keep these functions separate and separate in turn from outward trade promotion which is NZTE's core role.

21. **Enterprise New Zealand (ENZ).** The complex network of difficult-to-navigate industry support and mentorship services of Callaghan Innovation, technology incubators, industry grants, pre-seed and seed funds would be integrated to form a separate agency focused on start-up and scale-up (provisionally called **Enterprise NZ**). NZ Growth Capital Partners (and its Elevate and Aspire funds) should continue as at present but might merge at a later date into Enterprise New Zealand.

22. These two agencies and their single-entry points would provide the needed clarity, seamless advice, accessibility and support to the range of key stakeholders as part of the high-growth innovation sector.

23. **The CRIs.** New Zealand is unusual in that so much public research is operated through the CRI system, which effectively has the same shape and focus as was the case at its formation in 1991. This unchanged structure has created a constraining narrow path dependency to our research portfolio. Many aspects of the CRI portfolio fit appropriately into a PRO rather than (say) a university, in that the CRIs have primary roles in stewardship research (data collections, collection management, natural hazards research, monitoring, etc.). Some CRIs also have important and sustained industrial partners, and these relationships can readily be maintained and indeed fostered in an amalgamated model with a clearly stated mission of adding value by promoting transfer to the innovation sector. Furthermore, these organisations, which are small by international standards, are showing mission creep, and they compete with each other largely because of their commercial model and associated incentives. Such competition for activity and income to support institutional needs rather than giving priority to meeting the needs of 'NZ Inc.' is wasteful and does not well serve the needs of the Crown (the shareholder). The commercial model of the CRIs is unique amongst small, advanced economies (SAEs) and creates some of these problematic consequences and barriers to innovation. Over time, the CRI model has meant no adaptability in the overall shape of the PRO system as some scientific fields emerge and others decline. Primary production and the environment remain the focus and must be supported, yet in other key areas such as advanced technologies we have fallen well behind where we should be.

    While we considered other options including simply changing the legal structure, partial merger or a full merger with universities (as in Denmark), we strongly recommend establishing a new agency (PRONZ) with a single board of highly experienced science/innovation and science policy leaders represented at the highest level with strong scientific and end-user advisory input. However, this integration must be manged carefully over time. Simple partial mergers should not be the final form as this would leave the risk of duplication, inherent inefficiencies and challenges to having adaptable capabilities sustained into the future. The goal to be achieved within a finite time would be a responsive organisation built around capability groups formed of science teams focused on addressing New Zealand's needs including those linked to specific industries. This is a model which has many similarities to the Singaporean A*STAR model which in turn is evolving into this more flexible model. The focus should be on realigning the science activities, including partnerships and shared platforms, to match evolving national needs and to avoid duplication. This need for partnership extends to the university sector. Key to the model is a high-quality board including policymakers, business and academia, an expert and effective scientific advisory board, and a willingness over time to be adaptable as to how the assets of the PRONZ are organised – for example into hub-and-spoke activities with other parts of the research and innovation sector.

Rationalising back-office functions and in particular technology-transfer organisation functions will need to be addressed in due course. But it is essential that the initial focus of restructuring must be on defining an overall strategy (which in time will lead to activity realignment) and promoting effectiveness as the primary goals, leaving issues of efficiency until later.[5]

The future of the Institute of Environmental Science and Research (ESR) may be different; its primary role is service delivery, and it (or part of it) might be better integrated as an agency providing service functions into the Health and Police sectors. Alternatively, it may be a distinct platform entity within the PRONZ.

24. **Callaghan Innovation.** Callaghan Innovation is generally seen to not have met its promise, in part because the original design contained inherent conflicts. Those components of Callaghan Innovation's science functions that have a future or essential service focus (e.g. metrology services) should be integrated into the PRONZ. Other components of industry-focused activity should be tested against the market to decide on whether they are continued. The outward-focused innovation components of Callaghan Innovation will become part of **Innovation NZ** and the incubator-support, grant and mentorship components part of **Enterprise NZ**.

    The future of Gracefield campus, which has many issues that suggest it may not be appropriate for further investment as a governmental R&D site, should not be allowed to compromise consideration of this proposal.

25. **New Zealand Trade and Enterprise (NZTE).** Those components within NZTE that relate primarily to the innovation sector should be relocated to form part of INZ. Trade promotion and export-assistance functions are quite distinct from those of attracting major companies and investment, especially in the deep-technology space. Other countries separate these roles.

26. **Future Technology Initiative (FTI).** It is self-evident that rapidly evolving technologies are changing the world of knowledge, power and economics. Currently, most obvious is artificial intelligence (AI), but quantum technologies and advanced life science technologies such as synthetic biology will have very large impacts, and the time horizon for them doing so is much shorter than most realise. New Zealand is well behind other small nations in developing and applying these technologies. New Zealand needs to take a proactive role in ensuring research and innovation in areas where it could have competitive advantage while recognising the impact of these technologies may become the single biggest driver of increased productivity.

    AI will change the way governments work, change the use of data in policy formation, change research itself, affect how businesses operate, and have security and geostrategic implications. It will have enormous impacts on productivity. AI-based research and development in New Zealand will not be primarily based on the basic science of AI but on its application. There are many opportunities, but issues over data privacy, access and oversight must be addressed. Data sovereignty concerns must be addressed rapidly. Quantum computing and technology is likely to have a particularly major impact on financial systems and national security.

    Regardless of our future geopolitical positioning, New Zealand may be forced to think through how it positions itself in relation to the evolving global polarity, which is itself driven by and driving distinct technopoles. We urgently need people trained in quantum computing. A decision on a domestic quantum computer or developing a partnership with Australia will likely be needed within a relatively short time. Our research infrastructure in high-speed networking and supercomputing (NESI, REANNZ) is already under stress, and MBIE is having to make important decisions, which they have consulted the SSAG on.

5 We note that MBIE recommends the merger of MetService and NIWA. We were consulted by MBIE and support this consolidation, which does not affect our overall recommendation for a single PRO. Indeed, the advantage of a single PRO means it could operate both research units and service platforms efficiently and effectively. For example, the Measurement Standards Unit in Callaghan Innovation, which is an essential scientific service for industry, would be a platform that could be relocated to this model.

Rather than being a distinct agency, we propose the Future Technology Initiative is a virtual platform directed by the Ministry to invest funds strategically either in public good activity or to support the innovation sector. The initiative is intended to support pillars of future technology research and innovation, both within the public (including the security and defence) and public-private sectors. A particular need is for extension services to assist Small and Medium Enterprises (SMEs) in using AI effectively – our corporate digital maturity is not high.

27. **Technology Transfer Organisations (TTO) and related barriers.** The current SI&T system is full of practical barriers, and our recommendations are designed to reduce these and to promote connectivity across the entire public and private sectors in research and innovation.

    The most obvious barriers are between CRIs and universities, and between both of these and the private sector. They are a consequence of the commercial models of the CRIs and the institutionally focused incentives on both the CRIs and universities, which work to advance their own interests rather than advancing the value of the invention itself and the wider benefits to New Zealand. What has been created is a system full of legal bureaucracy, unrealistic valuations and approaches to IP, and a relative lack of incentives for scientists in universities and CRIs to innovate towards commercial value. We have noted examples of egregious behaviours in these institutions which have inhibited private sector development. In turn, the overhead rates under current models in both CRIs and universities inhibit private sector engagement and use of academics and researchers in their innovation pipeline.

    The panel's second report will detail several solutions. Most critically, a single set of standards should apply to all technology transfer organisations working for universities and CRIs (which would be reduced to one if the PRO is formed), they should not be allowed to sit on IP where it is exploitable, rules should exist about how equity is handled, and a master agreement should be put in place between the universities and PRO. Such standardised approaches are in place in other jurisdictions. Staff in both CRIs and universities should share the same benefits in any inventions they make. Staff should be allowed a period of secondment to assist companies they helped spin out.

28. **Independent research organisations.** There is a broad and evolving range of independent research organisations, ranging from Cawthron Institute to small regional or iwi-focused activities. Some provide critical support to national public interests as well as to the industries they are aligned to. Some are well supported by the Crown through mechanisms such as the SSIF providing core or platform support. Nothing in this report is intended to undermine these valuable relationships, rather the structure proposed will assist them strategically and operationally.

Some general considerations

29. Three factors underpin many of the issues we address in this report.

    a. Firstly, we have an underfunded system by any international comparison. This parsimony has led to harmful inter-institutional competition in a manner that is both wastefully expensive in terms of process and scarce researcher time and is known to inhibit the most intellectually innovative ideas coming forward, and of course it is these that can drive a productive innovation economy.

    b. Secondly, the SI&T system is a relatively over-managed and compliance-ridden system with inbuilt inefficiencies; a higher trust model with its greater efficiency and effectiveness is needed.

c. Thirdly, the corporate model for both CRIs and (effectively) for universities and the associated incentives lead, in the absence of mechanisms as suggested above, to many decisions that are not being made in the interest of value being created for New Zealand but rather for the benefit of the institution, even if it compromises development of the product.

30. **Priority setting.** New Zealand cannot do everything. We are a small part of the global scientific enterprise. But we have generated 'unicorns', and the 1930–2000 period showed how we relied on agricultural research to build our economy. In the rapidly evolving technological era we now have entered, we are forced to make choices. Priorities must be set by the PMSTIAC and the Ministry, and informed by the NRC, NEC and NIAC. In general, we will have to build off our demonstrated excellence and competitive advantages. Technology is changing the nature of science-based innovation. We must avoid disciplinary silos, as boundary crossing should be an advantage in a small country. The importance of social science to policy formation, to technology-based developments and to addressing challenges to our future should not be understated. Overall, the science and innovation system need strategic prioritisation beyond our undoubted and often unmet needs in stewardship and policy-related research. This will be a focus of the second SSAG report.

31. **The workforce.** Science and innovation are based entirely on human capabilities, well trained and entrepreneurial in their thinking. However, STEM education in schools is generally weak. It is very expensive to train a high-quality researcher, yet our early career workforce is highly precarious and often misused. This precarity is a function of the system, funding limitations, and attitudes by PROs and universities.

    The nature of our workforce does not reflect either the current or future more diverse demography of New Zealand or the reality that many science/technology graduates have their future in the private sector. The future workforce must build its Māori and Pacific Peoples workforces by investing in capacity and capability initiatives.

    Entrepreneurship is not, as in other countries, core to undergraduate education. This is a matter being discussed with the UAG. But at the same time, we have a relative shortage of key research opinion leaders (KOLs). These people form the focus for world class research activities, international partnerships and the attraction of innovation capital, in particular from multinational companies (MNCs). The attraction of KOLs should be a strategic priority, identifying strategic needs and seeking unequivocally world leading individuals.

32. **Leadership.** The proposed new architecture is reliant on the recruitment and appointment of talented individuals of the right calibre. Furthermore, the SI&T system under this new operating model needs to move from a low-trust environment to a much higher-trust one. The key entities also need cross-representation to maintain coordination and cohesion across the policy, funding and decision-making layers. Expert change management will be needed if change is to be effective and not disruptive.

33. **Multinational Corporations (MNCs).** MNCs are core to every advanced nation including the SAEs. They create a local market for smaller start-up companies (e.g. Rocket Lab has spawned many smaller activities), they bring global connectivity, and they are a source of entrepreneurs who understand going global from the outset. A core role of the NIAC will be to attract research activity of MNCs to New Zealand or to help New Zealand companies link to MNCs. But New Zealand must get beyond its somewhat xenophobic attitude to attracting companies, entrepreneurs and scientists with its current restrictive immigration and house/land ownership policies and the impediments created by the Foreign Investment Funds (FIF) tax regime for

migrating tech entrepreneurs if we are to be fully engaged in the intense competition for talent, foreign direct investment (FDI) and ideas.

34. **International science and diplomacy.** New Zealand cannot do everything in science on its own. We need to be internationally connected and this must be more strategically managed. The potential to do this in Australia and Singapore is underexploited. The entry into Horizon Europe is welcome but cannot address issues within the future technology space. The new Ministry must give greater attention to international science opportunities. Science and innovation diplomacy have not been a recent focus. Yet most countries are investing in science and innovation diplomacy for security, technology access and economic purposes. Our position in the Pacific and as a critical Antarctic stakeholder makes a greater focus essential. Climate change and the sustainability crisis dominate the international agenda. Science diplomacy is essential to New Zealand in these domains and offers areas of great opportunity.

35. **Investment.** Beyond the needed public investment, it would be important for the broad range of New Zealanders to feel that they are part of the innovation journey. Many countries do so by investing small amounts of sovereign funds in the local innovation economy. Already the Elevate fund administered by NZ Growth Capital Partners (NZGCP) has done so on behalf of the NZ Super Fund, and the venture capital sector commends this as an important element albeit that it may need some modification for greater adaptability. Such approaches should be encouraged across ACC, KiwiSaver funds, etc.

36. **Other Government SI&T entities.** There are many other components of Government that invest in R&D to support their policy or service delivery roles. The issues of oversight, focus, contracting, quality assurance and utility of such investments are part of the SSAG's terms of reference and will be addressed in our second report. Furthermore, there are agencies maintained by other ministries, such as Antarctica New Zealand and the Defence Science & Technology (DST, formerly the Defence Technology Agency), and research infrastructure such as the census and Integrated Data Infrastructure, that also need consideration. These will be considered in the next report.

37. **Data policy.** As the world moves to use data at scale, data needs to be interoperable between many types of users especially in research and policy development. Data policies must become a whole-government, whole-society focus. In turn this requires attention to social licence and privacy matters, oversight of Government use, etc. New Zealand cannot use data optimally and apply it in many ways unless the data sovereignty issues are resolved, and clear protocols are established.

38. **Transitional arrangements.** While this review recommends substantive change, this should be managed in a careful and ordered manner so as to achieve the most important and urgent gains at an early stage. We recommend giving priority to establishing PMSTIAC, to establishing a transitional governance arrangement towards integrating the CRIs and focusing on their science strategy, to developing the future technology initiative, and to establishing INZ and ENZ. Administrative approaches could be used in the short term to address a number of the barriers identified between public research and innovation.

Final comments

39. The SSAG is very cognisant of New Zealand's unsatisfactory fiscal situation and challenging outlook. It is clear that we must change strategies to achieve growth that will allow the country to have that broad social, economic and environmental wellbeing that characterises the New Zealand narrative. The global evidence for the role of SI&T in driving productivity growth is unequivocal and increasingly obvious. We stand frustrated by the apparent and persistent inability of the policy community in New Zealand to comprehend that reality. We note the bemused commentary of other nations and experts when we discuss the inability of New Zealand over decades to accept this very clear economic understanding. The SSAG stands firmly of the view that our parsimonious attitude to research funding is a core reason that New Zealand has become an outlier in performance on productivity growth. The urgency of now addressing this is made more acute by the rapid shifts in economic productivity based on AI and other technologies. New Zealand is truly at an inflection point and an urgent critical choice must be made. Investing in science and innovation should not be a partisan issue, rather it provides the chance for New Zealand to secure a prosperous future.

40. New Zealand is a multicultural society based on bicultural underpinnings established by the Treaty of Waitangi, which is core to New Zealand's identity. It is essential that the science and innovation system is inclusive and beneficial to the diverse fabric of New Zealand's society. Māori have a particular relationship with the Crown, and the context of this relationship extends to the unique knowledge systems that are inherent to Māori history, identity, values, culture, ancestry and economic well-being. The SSAG acknowledges this in making its recommendations.

41. This initial report has intentionally focused on the high-level architecture of the research and innovation system. It is accepted that further detail is needed, and this will come both through further consultations with the sector and work with the Ministry, subject to advice from Cabinet on the general shape of the proposed architecture. Any change must be carefully managed, but the need for change is unequivocal and urgent.

42. If the SSAG's recommendations are adopted, they will promote a more diverse and productive economy, align our policy settings with those of much more successful SAEs, and allow for better stewardship of our nation's social and environmental resources. It will also assist the current and future governments in responding to the immense challenges that rapid social, technological, geostrategic and environmental changes are bringing.

Introduction

43. Cabinet established the SSAG on 25 March 2024. Its terms of reference and membership are appended. Its primary purpose is to examine the needs of New Zealand from the research, science, technology and innovation sector and make recommendations for the Government to consider that would lead to a greater contribution from the sector to New Zealand's economic, social and environmental development and to addressing the multiple challenges we face, ranging from climate change to poor productivity. It is accompanied by a separate review into the university sector, and there is high-level coordination between the two reviews.

44. The first stage of the review is intentionally high-level and designed to focus on the purposes of science, innovation and technology (SI&T) for New Zealand, identify the issues to be addressed and the architecture appropriate for the coming decades. The second stage will take a closer look at components of the proposed sector architecture if it is agreed by Cabinet, and at their key operational dimensions.

45. It is recognised in every advanced country that SI&T are central to a country's productivity and economic growth, with both direct and indirect contributions essential to a nation's human, social and environmental wellbeing. Other nations are increasingly making SI&T the centrepiece of economic strategy, particularly given the pervasive and accelerating impact of major science-based technology advances in areas such as artificial intelligence (AI), synthetic biology and quantum computing.

46. New Zealand has historically been an outlier in making SI&T a core part of Government's economic strategy, despite robust evidence that in the decades prior to 2000, it was our agricultural research that allowed our country's economy to grow and sustain New Zealand as a developed country. If New Zealand wishes to continue to improve its position, it is not enough to simply absorb innovation produced elsewhere; we must build science capacity and capability to innovate and enhance our productivity and wellbeing.

47. New Zealand faces major and existential changes: poor productivity, the need to diversify its economy and export profile, the issues of climate change, multiple sociological issues, and the need to grow its wealth to meet the expectations of its citizens. It is obvious that rapid and urgent change in its productivity and economic profile is needed. Research, science, technology and innovation are central to addressing these challenges.

48. We are at a key decision point as a nation. The pace of change in technology cannot be ignored, and how societies respond will determine much about their economic futures. New Zealand must diversify its export economy while building on its strengths and urgently addressing its productivity challenge if standards of living are to increase or even be maintained in the face of external and internal challenges. Without exploiting our capabilities in research, science, technology and innovation, we are unlikely to meet these challenges in ways that are acceptable.

49. Cabinet has recognised this in listing science and innovation as one of its five core strategies for economic growth. The establishment of the SSAG by Cabinet is itself a recognition of the need for urgent attention to the science system, and as the Cabinet paper notes, significant structural change is likely needed.

50. The SI&T sector has many components (see figure 1). The most obvious delivery components of the public research system are the CRIs and universities. Beyond that are the activities undertaken or contracted by government departments for multiple purposes, and multiple funding instruments across several ministries. Beyond that are the various technology transfer

mechanisms and supports to provide sector innovation. Across all this landscape there is an obvious and deleterious void in strategic alignment and integration. The system is fragmented, with poor visibility of the effectiveness of current investments, and it suffers from duplication, inefficiency and poor use of resources. These enduring structural challenges get in the way of it delivering value to New Zealand.

51. The current science and innovation system is a patchwork arising from multiple decisions made over many years without an integrated high-level view of the strategic goals of SI&T being reflected in the individual decisions made. Several significant problems have been identified, some reflected in the Cabinet paper and in the Terms of Reference of the SSAG, which mean that New Zealand is falling behind in using research and science to drive future commercial and societal benefits. It is important that the report that follows is seen as an integrated set of recommendations to be implemented as a whole if we are to achieve the outcomes in productivity and wellbeing that both the government of the day and hopefully all political parties, the private sector and citizens would desire.

52. Government has the central role in driving change using SI&T. The outcomes will not be instant but require commitment to a long-term vision crossing political cycles, as they require increased investment, structural change to remove barriers and unnecessary duplication, and a long-term systematic and strategic approach to policy development and evolving the SI&T ecosystem. We recognise we are in very challenging economic times, but it is in such times that investments for greater productivity and social benefit are essential. This is the unique value proposition of investment in SI&T.

53. MBIE is primarily responsible for contracting SI&T to meet New Zealand's broader needs through a variety of mechanisms, but other ministries (e.g. Education via TEC, Health for HRC, MPI etc.) are also directly involved. Further, a large amount of research is directly undertaken or contracted by government departments and agencies, with variable levels of oversight and quality control.

54. Contracting of public-good research happens via several mechanisms, of which the Marsden Fund, Endeavour Fund, Health Research Council and the Centres of Research Excellence are the largest components along with direct contracting by ministries. The research system has multiple delivery components, most notably the universities, the CRIs and a scattering of smaller independent research entities.

55. End users of research are businesses, Government, iwi and the community, but a variety of barriers limit effective uptake of knowledge from the public sector. These barriers are both cultural and structural. Overall, businesses and even government departments find access to universities and CRIs slow, expensive and bureaucratic – the exceptions reflect some deep sectoral relationships with some CRIs, which must be maintained after reorganisation. Business itself is increasingly investing in R&D, but international experience demonstrates that without greater strategic consideration, system integration and aligned meaningful public investment giving the business sector the confidence to invest further in R&D, we will be unable to compete effectively in a technology-focused world.

56. Early-stage innovation (start-up and scale-up) ventures require specific support mechanisms, which themselves are spread in multiple agencies and schemes, creating confusion and complexity. As companies seek to be global from the outset, the problems of accessing capital and expertise illustrate that we do not have an effective agency structure to maximise the potential of science and innovation for our economy.

57. Fundamental architectural change is needed spanning the whole system and to ensure strategic oversight and direction over all its components.

58. The current research and innovation system was largely designed in 1991 when DSIR was broken into the CRIs, which stand somewhat isolated from the university sector. There have been various iterations of policy, ministries and funding agencies. The current form relies heavily on MBIE as policymaker, funder and decision-maker. Callaghan Innovation was established in 2013 to improve commercialisation, start-up and scale-up, but from the outset it had a somewhat conflicting mission. Several other agencies are also involved in the innovation pipeline, including NZTE, NZ Growth Capital Partners (NZGCP), technology incubators and pre-seed funds (KiwiNet, UniServices, etc). Additionally, there are tax credits provided to the R&D sector (these were outside the SSAG's terms of reference).

59. In sum, the system is confused and overly complex for its size, characterised by multiple barriers (see below), costs that are inhibitory, a low level of overall investment and a sense that New Zealand does not have a system designed for the technological age. There is an overwhelming consensus that there is a need for a significant redesign of the sector that is appropriate for an age in which technological and science capabilities will drive productivity even more strongly than in the past and address the many complex problems that countries face.

60. Ultimately, the aim is to ensure New Zealand remains a small but robust advanced economy. The review has identified many ways in which the system is inhibited and can be improved.

> *[There are] ten important attributes for a successful RDI landscape, including values that ensure the pursuit of research is the pursuit of truth. These attributes are high research quality; agility and flexibility in approach; permeability between sectors, disciplines and organisations; transparency and navigability for those seeking to engage with R&D; a skilled workforce; inspirational leadership; a good research culture embracing ethical behaviour; strong international collaboration; and financial sustainability. The recommendations of the Review aim to strengthen these areas with the ultimate objective of empowering researchers (and innovators) so they deliver a research endeavour that drives the economic, societal and strategic benefits necessary for the future success of the [nation].* Sir Paul Nurse[6]

61. The SSAG cannot overemphasise the urgency for fundamental strategically informed change, but the process of change must not further undermine the efforts of the research, scientific and technological communities, for, in the end, successful SI&T is a function of human capabilities and the system that supports those in it.

62. Despite these challenges, New Zealand should be proud of the contributions New Zealand science and innovation has made to our economy and wellbeing. But overall, the scientists and innovators driving the system are being asked to do too much in a system that is failing, barrier-ridden and no longer fit for purpose.

63. Several factors stand out for consideration as we look to the future:

    a. The potential for all forms of research to contribute to the nation's development is poorly understood. This unexploited capability extends across the humanities, creative sector, social sciences, and the natural and technological sciences. Many of the persistent or 'wicked' problems[7] cannot be addressed without greater use of actionable knowledge that

6 Nurse, P. (March 2023). *Independent Review of the UK's Research, Development and Innovation Organisational Landscape*. https://assets.publishing.service.gov.uk/media/6409fda2d3bf7f02fef8832b/rdi-landscape-review.pdf

7 'Wicked' problems are those that seem impossible to solve because of numerous interdependent factors, which are often difficult to define, incomplete and constantly changing.

emerges from research. The issues of climate change, intergenerational disadvantage, social cohesion, mental health, low productivity, etc., all require more integrated use of sciences and knowledge.

b. The nature of knowledge, research and SI&T is changing. Digital (e.g., AI, quantum) and life sciences technology (e.g. synthetic biology) are fundamentally changing research and SI&T systems, economies geostrategic and power relationships. We are experiencing the biggest change in centuries in how knowledge is developed and applied, but New Zealand is at risk of being left out of the first world of knowledge generators and users, an outcome that would impact on every aspect of our economic, social and environmental futures.

c. New Zealand has only five million people and must earn its relevance in the world. But being five million people means it cannot do everything in SI&T alone. It must make choices, and it must seek greater partnerships to succeed.

d. In the future, Māori and Pacific populations will comprise a significantly larger portion of the research workforce. However, their potential contributions have been hindered by shortcomings in the current education system. These deficiencies must be addressed to ensure an equitable and inclusive research and innovation environment.

What is the value proposition for a more effective system?

64. New Zealand is at a critical point in its history. Our economic performance compared to many other western nations shows a continuing relative decline, especially evident when we examine other SAEs, which have much in common with New Zealand. With a small population, located at a distance from larger countries, we can easily be ignored. In today's rapidly changing world, we need to be nimble, open to new ideas and, as far as possible, align ourselves to take advantage of economic, technological and scientific opportunities. Without a high-quality, efficient and effective research and innovation sector, our absorptive capacity for new knowledge for our nation's advantage and our ability to be relevant in a world trading on ideas, data and technology will be compromised.

65. We are the outlier as a country in our policy settings and increasingly in our performance. Every other country that shows higher productivity growth compared to New Zealand decided some years ago to invest more significantly in R&D, and a number are reinforcing and increasing that commitment now, even in the face of ongoing economic difficulties. The European Commission and OECD have recently issued significant policy statements of the need to do so. Failure of New Zealand to similarly respond will lead to further deterioration in our standard of living relative to other countries. Quite clearly, the status quo will not deliver the necessary nationwide changes needed to reverse these long-term trends.

66. There are multiple ways in which research generates impact and creates value. Common misunderstandings such as the linear or sequential model of innovation can lead to a significant underestimation of the value of research. The public research base should be engaged in a continuous process of knowledge exchange with users in business, the public sector and social organisations. Benefits extend beyond both the producers of research and those owning the results through knowledge spillovers, market spillovers and network spillovers, meaning that the social rate of return exceeds the private rate of return.

67. Innovation takes place within an ecosystem, and that has important implications for the institutional and regulatory environment in which research and innovation take place. Studies emphasise the need for public research to overcome 'lock-ins' to existing solutions, the

importance of coordinated approaches, particularly towards societal challenges and complex systems, the importance of infrastructures, and the value of foresight as a means of countering bounded vision.

68. Numerous studies have addressed the rate of return on the public investment in research, and the strong consensus is that the rate of return is high, even though there are obvious methodological challenges. According to most studies, the overall value generated by public research is between three and eight times the initial investment over the entire lifecycle of the effects, and when calculated as an annual rate of return, ranges between 15 and 50%.[8]

69. Studies of OECD countries show the clear complementarity between public sector R&D and business sector R&D. A study (see figure 5) of the investment by SAE governments in R&D and that by the private sector done in SAEs shows that as a fraction of GDP, the relationship is about 1:1 at low levels of public investment, but once a critical point is reached – a level significantly higher than New Zealand spends from the public purse – private sector investment rises faster in an exponential fashion. This reflects the maturation of the ecosystem, the need for a critical volume of ideas flow to support investment, and adequate provision of a research-trained workforce flowing to the private sector from the public research sector. This relationship can also be demonstrated longitudinally when one examines OECD data on an individual country such as Denmark. While private sector investment in New Zealand has risen as the angel, and the entrepreneurial and venture capital community has matured in recent years, it is unrealistic to imagine growth of the level desired and comparable to other countries without considering the central role of the State as the anchor investor.

70. There is global recognition of the critical role of R&D in economic, social and environmental wellbeing. The European Union, for example, has recently issued a report outlining how R&D is fundamentally important across many domains.[9] The writers summarise, "research and innovation (R&I) efforts are pivotal for Europe's future, offering sustainable solutions to societal, economic, environmental, and political challenges," … "R&I is crucial to boost Europe's (long-term) competitiveness and to improve living standards." They note that R&D is also required for economic and societal resilience, meeting the EU's climate objectives, and advancing health outcomes.

71. Every small, advanced economy (SAE) to which we would wish to compare ourselves has for decades been far more certain and aggressive in using SI&T as the basis of its economic development. It is extraordinary how distinctive New Zealand has been in this regard, and the consequences of this policy void and contrary position are now manifestly apparent. It is more extraordinary given that it was agricultural research in the 1950s–1980s that has in many ways sustained our economy to date. Although much about our respective R&D sectors is different from those of other countries (e.g., in scale, fields of strength, etc.), the impact of R&D appears to be profound whatever the context.

72. R&D intensity (the sum of public and private non-defence spending on R&D) correlates strongly and positively with labour productivity. Poor productivity has long been a weak feature of the New Zealand economy, which matches our low investment in R&D. Second, countries with higher quality of life are those with more innovative economies.

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8 Georghiou, L. (2015). *Value of Research Policy Paper by the Research, Innovation, and Science Policy Experts (RISE)*. European Commission, Directorate-General for Research and Innovation. https://ec.europa.eu/research/innovation-union/pdf/expert-groups/rise/georghiou-value_research.pdf

9 European Commission. (2024). *Why investing in research and innovation matters for a competitive, green and fair Europe – A rationale for public and private action*. Directorate-General for Research and Innovation. https://data.europa.eu/doi/10.2777/01237

73. Sceptics might dismiss these findings as correlative, not causal. But a previous analysis of countries like Denmark, Singapore and Israel demonstrates the central role public investment in R&D plays in driving the economy. Nevertheless, the EU is concerned about its R&D sector. The same report[7] notes that "R&I investments in the EU fall short of its aspirations and compare poorly to global competitors. R&D spending stands at around 2.2% of GDP, well below the 3% objective" (New Zealand's R&D spend is 1.45%). This concern shows just how important the EU thinks R&D is to its future wellbeing.

74. The conclusion is inescapable: more investment leads to higher living standards. Senior officials from countries such as Israel, Singapore, Denmark and Finland have been surprised at New Zealand's persistent and wilful resistance across several administrations to acknowledge and act on the key role of R&D in driving productivity and economic growth. More recently, a New Zealand Productivity Commission report suggests that New Zealand's productivity gap is likely to be associated with its poor performance around R&D.[10]

Implications for New Zealand

75. What lessons can we take from these analyses, which are not novel, for New Zealand? Since the 1960s our relative economic performance has declined, to the point where soon we may not be able to catch up and continue to be regarded as one of the world's SAEs. This situation has come about in part through a refusal by Government and business alike to have a strategic view of R&D and to invest in it appropriately over the past 30 (or more) years. And as we now face an extraordinary period of rapid technological acceleration around the world, the prospect is that we are left even further behind unless we make some urgent decisions, followed up by significant action.

76. Without apportioning blame, the failure of strategic insight in public policy over many years to understand the need for an appropriate level of investment in R&D has, in retrospect, been crippling. We must now follow the example of rapidly emerging economies and reverse the trend (while acknowledging every country is working in a different context).

77. Much of the problem here arises from:

    a. A national culture that has regarded R&D as a 'cost' rather than an essential investment.

    b. A narrow view of what R&D can do for national development. Governments to date have emphasised short-term economic benefits. It is easy to make a political argument for such close-to-market interventions, but real transformation requires a full innovation pipeline, delivering economic, social and environmental benefits over the long term.

    c. Deferral and no sense of urgency. While successive governments have, over the years, committed to improved funding levels, in each case these initiatives have fallen by the wayside.

    d. Poor strategic leadership and strategic approach across the system, and an unwillingness to make strategically informed choices. Some clear cases of institutional failure have been poorly addressed.

    e. Too often there has been inappropriate, politically driven, short-term decision-making in the R&D sector rather than the sustaining, long-term, expert-informed decisions that have New Zealand's long-term interests at the forefront. This problem is exacerbated by our three-year election cycle. Assembling a cross-party consensus on the importance of a strong R&D sector would alleviate this issue to some degree.

10 New Zealand Productivity Commission (2021). *New Zealand firms: Reaching for the frontier.* Final report. www.productivity.govt.nz/inquiries/frontier-firms/

f. Inadequate funding has led to multiple perverse incentives for both institutions and researchers. An underfunded system leads to conservative, 'safe', short-term research, rather than engendering the transformative investigations of intellectually novel and 'risky' innovation. The result is a system with shallow research capabilities, which is slow to respond to challenges.

g. Chronic underfunding has led to poor career structures for researchers and a concomitant reduced ability for research organisations to manage human capital in ways that allow for agile responses to research challenges.

h. The system still has too much focus on past rather than future needs and a focus on the state of the institution rather than the state of knowledge and its application. Many of the incentives in the science system focus on the institution rather than maximising the utility and application of the knowledge developed.

i. Innovation is inherently future focused, so the inertia characteristic of many parts of the New Zealand research sector is a significant impediment to the country's requirements. We should be aiming for a responsive, nimble system that is firmly future focused.

78. Gaps and barriers in our innovation system remain unaddressed. Gaps in our R&D sector are partly a consequence of the way in which the CRIs were set up 30 years ago. Dividing the DSIR into separate CRIs corresponding to different areas of research in 1991 may have been logical and defensible at the time, but the structure of the CRIs has been incapable of filling newly arising gaps, even those that have significant economic consequences, for example those related to new technologies. Universities, with their emphasis on cutting-edge research, may have been better placed to fill gaps, but their work is too often divorced from the private sector's innovation and workforce interests. Collaboration between researchers in different research organisations is often hampered by institutional interests. There are significant (and increasing) compliance costs.

79. There is a lack of recognition of the need for international partnerships. Science is a global activity. New Zealand's geographical isolation risks intellectual isolation unless we actively encourage international collaboration. It is now evident that research productivity is much higher with international input, notably international co-authorship and higher numbers of foreign (but not domestic) PhD students.[11]

80. The quality of STEM education in schools is worrisomely limiting. The abilities of students leaving high school directly impact how and what they are taught in the tertiary education system. Our high-school curricula, designed to give students (and schools) significant choice, often mean that different high-school graduates have very different levels of knowledge. This issue is aggravated by very unequal access to science facilities and expert teachers. Consequently, introductory university courses need to cover material that some undergraduates will have missed but others will have already met.

81. New Zealand's past economic success based on R&D largely came from agriculture and primarily from increasing the performance of land-based industry rather than post-farm gate. Much of that came from decades of research at Ruakura, Massey and Lincoln in livestock development and farm systems management, and more recently the success of the kiwifruit industry depended critically on Plant and Food Research. But New Zealand's geographical position and climate change mean we cannot rely only on that sector, and we have seen the potential in deep-technology (Rocket Lab, LanzaTech, Apple NZ), in life sciences (Neuren

11 Bonaccorsi, A. et al. (2021). The research productivity of universities. A multilevel and multidisciplinary analysis on European institutions. *Journal of Informetrics* 15(2) 101129. https://doi.org/10.1016/j.joi.2020.101129

Pharmaceuticals) and the digital and entertainment space (Weta Workshop, Xero, etc.) of science and technology-based innovation. As the advanced technology sector matures, New Zealand needs to reposition its research and technology settings.

82. OECD data[12] demonstrates the strong relationship between total government investment in R&D and economic growth. It shows that New Zealand has a low research intensity (the sum of public and private non-defence spending on R&D) relative to countries it would wish to be compared to. The same data show a relationship between R&D spend and GDP per capita, and this is now well accepted elsewhere to be a causal relationship. Historically New Zealand has been a low investor in R&D. Its current expenditure is about 1.45% of GDP, with about 60% of that being made by the private sector, meaning that the total Government spend is only ~0.6% of GDP. This is minimal by global standards and relative to countries we would wish to be compared to. There has been a gradual increase in private sector expenditure over the recent decade, representing the emergence of technology companies, some of which have reached unicorn status. The stated goal in the European Union is that all member countries should have public expenditure of at least 1% GDP on R&D and 2% from the private sector, and countries such as Finland are now driving to a higher research intensity of 4%. New Zealand, with its low aggregate spend of 1.45%, compares poorly and looks more like the tier of developing countries in Eastern Europe, but all of these have strong policy positions to increase their R&D spend, assisted by European Union cross subsidies.

83. Table 1 and figure 3 below illustrate New Zealand's position relative to other countries. Also included below is the GDP per capita and the Purchasing Power Parity (PPP) nominal for each country.

Country	% GDP	GDP per capita (USD)	GDP (PPP) nominal (USD)
Israel	5.56	320	275
South Korea	4.93	157	246
Belgium	3.43	170	223
Switzerland	3.31	305	276
Austria	3.26	188	228
Finland	2.99 (4% goal agreed across parliament)	151	176
All OECD	2.95		
Denmark	2.81	188	207
Iceland	2.81	209	193
Netherlands	2.31	130	161
Singapore	2.16 (with a stated goal of >3%)	168	274
Slovenia	2.13	62	87
Norway	1.94	206	219
Australia	1.83	117	114
Estonia	1.75	50	81
Portugal	1.73	42	71
Hungary	1.64	29	68
New Zealand	1.45	69	75
Latvia	1.11	24	44

Table 1: Total non-defence R&D spend as a %GDP by country alongside GDP per capita and Purchasing Power Parity (PPP) nominal (World Bank latest numbers[13]).

12 OECD. (2018). *OECD Science, Technology and Innovation Outlook 2018: Adapting to Technological and Societal Disruption*, OECD Publishing, Paris. https://doi.org/10.1787/sti_in_outlook-2018-en

13 https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS?end=2022&name_desc=false&skipRedirection=true&start=1996&view=chart. The dataset also shows the direction of each country's spend, and New Zealand again looks static while most show growing expenditure.

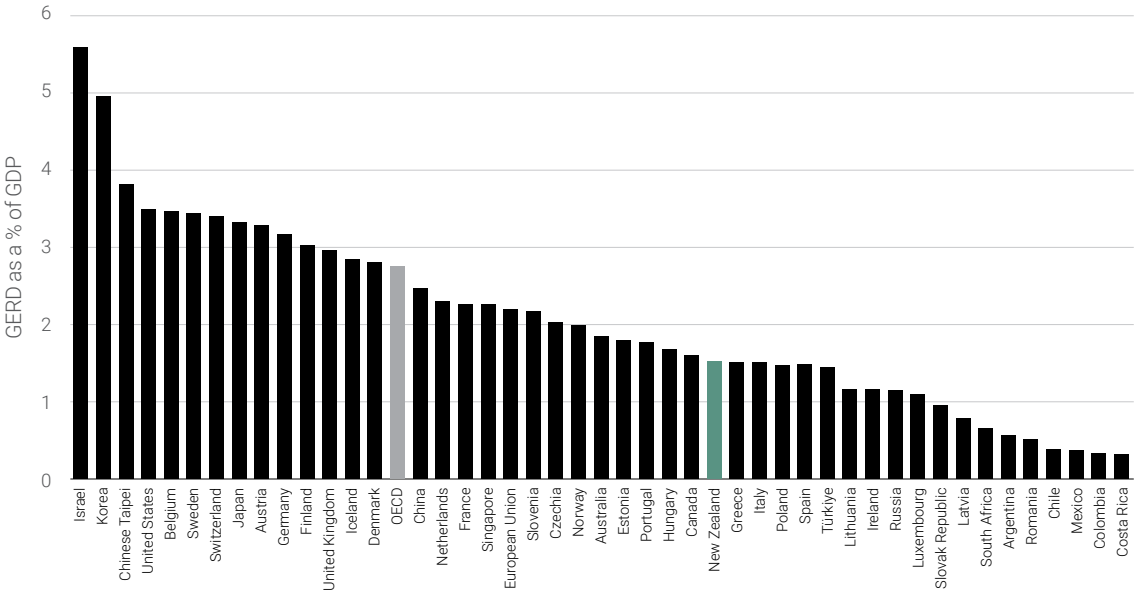

Figure 3: Gross expenditure on R&D (GERD) comparison by country (Source: OECD).

84. Figure 4 shows the relationship between gross expenditure on R&D (GERD) and GDP per capita by country. A high GERD/ GDP ratio is a key indicator of a country's commitment to R&D, technology and innovation, leveraging new opportunities, increased productivity and experience greater economic growth.

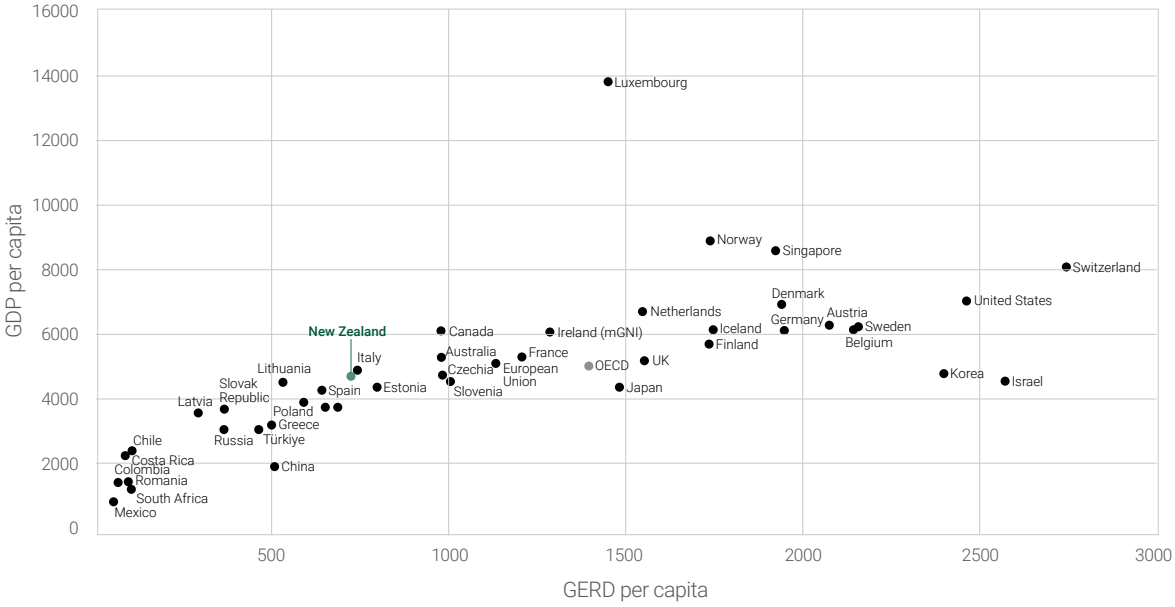

Figure 4: The relationship between gross expenditure on R&D (GERD) and GDP per capita (Source: OECD).

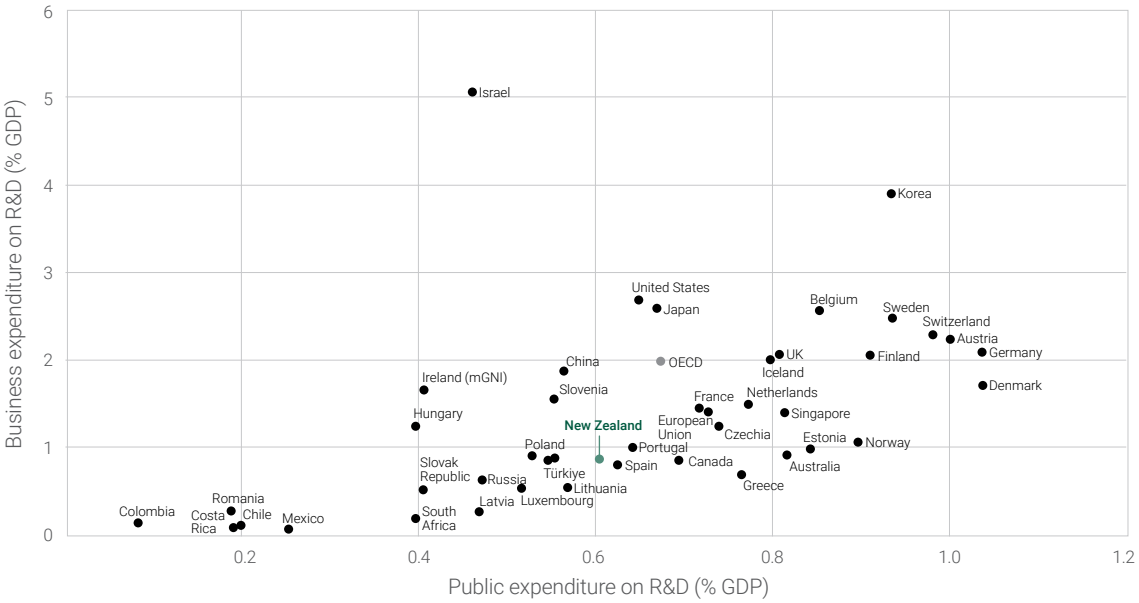

Figure 5: The relationship between public expenditure in R&D and business expenditure in R&D (Source: OECD).

85. Figure 5 shows that once government investment progresses above ~0.7 %, a relatively much faster rise in private sector spending occurs. This is accepted by policymakers from those countries as a causal relationship and can be demonstrated in longitudinal analyses of individual countries.

86. The international analysis is clear: we are spending significantly less than comparable countries spend from the public purse on R&D. The counterclaim, a persistent view of some officials in Treasury in New Zealand over many decades, has been that these correlations have no causal connection. This argument receives bemused responses from economists and policymakers in countries with which we would want to compare ourselves. If there really were no causal link, it is odd that none of our comparator nations nor the EU or the OECD buy into that argument. Not surprisingly, a recent economic analysis of EU countries[14] backs up the causal claim (and is consistent with previous studies). The authors emphasise that for countries with low expenditure, improved R&D activity is especially important for GDP growth. Indeed, almost all these countries have increased R&D expenditure in recent years. New Zealand should take note – it is an outlier both as a low investor and a poor economic performer.

87. The alternate argument sometimes advanced in the policy community is that New Zealand can rely on other countries' efforts and simply needs absorptive capacity. The lack of logic in such a statement is clear. Beyond our local research needs, of which there are a multitude of contextual issues, our nation's future will be partially determined by the export of knowledge – it is that increasingly weightless and value-added export growth that will drive the productivity gains that New Zealand needs.

88. New Zealand faces real challenges and can no longer be complacent. Its economic model, based largely on primary production, cannot sustain societal expectations into the future. Issues of social equity, education, health and the environment require economic investment. Our trade in commodities has kept us functioning but it cannot provide for the future we want and believe we deserve. Increasing innovation and relatively weightless exports are the future, and we cannot achieve that against a low flow of knowledge, capability and capacity to the private sector.

14 Freimane, R., & S. Bāliņa. (2016). Research and Development Expenditures and Economic Growth in the EU: A Panel Data Analysis. *Economics and Business* 2016/29. doi: 10.1515/eb-2016-0016

89. New Zealand academics and scientists are well regarded internationally – they are a real asset of the country.

90. The flow of ideas to the private sector is lower than it could be because of the state of our public sector R&D and the nature of its interface with the private sector.[15] There are multiple issues, including a focus on institutional health rather than the promotion of knowledge development for New Zealand's benefit. The public science system is full of compliance costs, lack of strategic oversight, or strategy and incentives that have perverse outcomes. The innovation system is small and fragile, and yet highly complex, confusing and not equivalent to those in countries with which we would want to compare ourselves. We must make our current system more productive, valued and effective. We must demonstrate why it is important that we, like other advanced countries, use knowledge development and application to improve our productivity, economy, social and environmental health. An effective SI&T system would bring rewards across all these dimensions to the country.

91. Because a SI&T system acts over decades, sometimes taking many years from early idea to exploitation, science systems should not be subject to partisan whims but should be seen as core elements to a nation's backbone and future. There is an overwhelming need for a broad consensus about the value of a strong SI&T sector.

92. But underpinning any strategy for New Zealand is the fact that we have underinvested, we are a tiny fraction of the global research endeavour, and we must make wise choices on how we use science and how we promote innovation. Many components will require greater global connectivity. But without being a knowledge generator, we will not sustain our relevance.

Types of research

93. While it is easy to focus on the direct economic potential of research, there are many other direct and indirect benefits: for example, enhancing effective stewardship and policymaking through robust evidence in areas which do not lead directly to appropriable outcomes. Such activity has real, albeit indirect, benefits for the New Zealand economy through its impact on social, human and environment policymaking. While much of the above commentary has focused on the direct benefits, non-appropriable research including in the creative arts, humanities, mātauranga Māori, and in domains of social and natural sciences is also critically important to being an advanced economy. It has cultural, social and inherent values.

94. There are many ways of categorising research which each have different purposes, the most common being to take a linear approach from basic to applied to development. But while that describes the modalities of research, it does not describe the purposes of research *from a policy perspective.* In thinking through *why* New Zealand invests in research, it may be helpful to think in terms of four classes of research that merit distinct consideration and potential distinct governance, strategy and management, and each of which provides distinct value to New Zealand's future. These categories need not be mutually exclusive, and within each there will be research that spans from basic to applied to developmental, but the different focus of each means that they may require different funding strategies and mechanisms.[16]

95. The following categories are designed not only to recognise investigator led, mission led and commercially focused research, also highlight where government agencies such as Ministry of Primary Industry (MPI), Ministry for Environment (MfE), Department of Conservation (DoC),

15 An analogy would be to build a hydroelectric dam and power station to generate power on a river that has insufficient water flow. Water is a metaphor for the wanted ideas and people flow, power is the metaphor for the wanted innovation and productivity gain.

16 Gluckman, P. & Sridhar, H. (2024). Framing public research investment decisions for the policy community. *Frontiers Policy Labs* (in press).

Defence, Health and Social Investment Agency (SIA), amongst others, have a clear role to play in defining priorities and indeed in funding or contracting. The possible mechanisms will be discussed in our next report.

Stewardship research

96. Stewardship research describes that research necessary for a government to ensure its basic obligations of stewardship.

97. Stewardship research includes the collection and processing, often over the long term, of basic data, and that research needed to protect the core human, social, economic and environmental assets of New Zealand. These activities provide backbone services or critical information that are needed by all well-functioning, modern economies to operate, enabling an economy or general society to function. Examples include measurement standards or monitoring natural hazards (e.g., volcanic ash assessment to support airlines). Stewardship research also underpins much government decision-making. Governments depend upon access to robust and consistent evidence to target resources, inform policy design and implementation, and meet statutory reporting obligations (domestic and international). Such data gathering includes recording changes in sea level and atmospheric CO_2 concentration, measurements for seismic-hazard modelling, GeoNet earthquake reporting, estimation of freshwater pollutant levels, the curation of taxonomic and other collections, the collection of economic and social statistics (e.g. Stats NZ's Integrated Data Infrastructure (IDI), which holds de-identified microdata about people and households). Some aspects of defence science, fintech, and cybersecurity research clearly fit that class of research.

98. It should be noted that although simple data collection does not fit the usual definition of research, it is that base data which is the essential fuel for subsequent scientific analysis and modelling. For example, the curation of arthropod collections includes taxonomic research essential for our biosecurity, and sea-level measurements require sophisticated mathematical analyses to remove the effects of tidal change. And it is important to recognise that data collected in this manner is also useful to researchers and industries outside Government: the IDI data is important for many of the social sciences; land use data is essential for many industries; and weather data is essential for farmers, etc.

99. Typically, stewardship research does not offer immediate or significant commercial value but is a critical investment to ensure the resilience of nature, communities, infrastructure and the economy. Much stewardship research could be classified as 'public-good research' and its results are often made widely available to, for example, researchers in PROs and universities, and commercial users. It will often be important that stewardship research is carried out in a way that maximises the utility of the results for a range of potential users. Consequently, it is natural for the central Government to support such research, probably through a non-contestable fund, since competition amongst providers is likely to lead to unnecessary duplication.

100. A particular form of stewardship research is foresight and technology assessment. Stewardship requires anticipating the future and in particular addressing, where possible, identified stresses and shocks. Formal methods exist to assist that process, but they are poorly used within the New Zealand policy community. Further, in a world driven by rapid technology change, the lack of an expert technology foresight and assessment unit supported by the Crown puts the country at risk of being a 'slow follower' in a world moving quickly.

101. The need for stewardship research is one core argument for retaining PROs as they are the primary, although not only, provider of such research.

Policy-focused research

102. Policy-focused research is that type of research needed or desirable to meet central and local government needs to make informed policy decisions. Often it may either drive more or use the results of stewardship research.

103. Types of research issues falling into this category include, for instance, the economic and/or social consequences of a possible tax change, or the effects of different predator-control strategies for threatened species. Evidence-informed decision-making relies heavily on this form of research. Using evidence in policymaking ensures that the Government is clear why and where it is spending money and should cause a better investment return.

104. Funding policy-focused research in New Zealand has been problematic. Some ministries have research capability in house (e.g., Department of Conservation, Ministry of Primary Industries). But the internal research capacity is vulnerable as ministries and departments seek to economise, and funds allocated for research become an easy target. What is needed is a clear understanding of the need for the research, the questions that need answering, and ensuring a methodology and analysis appropriate for that. Often such robust questioning has been absent, risking the value of the investment made, but such a statement should not diminish the need for and the value of such research to the policymaker.

105. Given the Government spends such a high proportion of its budget in the social sector, broadly defined, the importance of high-quality data-informed social sector research informed where appropriate by policy trials and the use of implementation and evaluation science should be obvious. Systematic use of robust quantitative social sciences could be enhanced.

106. Operational research is that research a government should undertake through its agencies to improve the efficiency and effectiveness of its agencies. This is particularly so in domains such as education and health which are data-rich, yet the level of investment in operational research is poor as a fraction of the total spend relative to what a private sector equivalent would spend. Some government agencies contract out operational and analytical research to one of the 'big four' accounting firms or consultancies.

107. The need for some such research to remain confidential (at least until policies have been set, but sometimes even after) also raises issues about quality control. In many cases, quality assurance has been unequal and the processes for deciding what should be funded are not necessarily of a standard that ensures utility of the result. Yet government agencies spend large sums, often without processes to ensure optimal performance. In contrast to discovery research, the results of Government's policy-focused research are seldom published, nor are they normally subject to external peer review. These linked issues – funding and quality assurance – need to be solved by a funding mechanism that preserves the appropriate degree of confidentiality. This, however, should not restrict the use of academic or other providers under appropriate agreements.

108. Departmental Science Advisors (DSAs) may have a role to play. In some government ministries, departments and agencies, practising scientists have been seconded for several years to provide science advice and connectivity to the research community. While some departments do not have such advisor roles, others have employed science advisors directly. The greater independence of the first (seconded) type of advisor suggests that they could, in principle, assist in quality assurance and connectivity. Further, the lack of a standardised role description and expectation for such roles has meant some departments have now exited them (Transport, DOC). It would be a priority in enhancing policy-related research to review the role of DSAs and the PMCSA.

Knowledge-generating research

109. Knowledge-generating research is that class of research where the primary driver is to produce new knowledge, perhaps simply for its own sake ('pure-basic research' in the terminology of Pasteur's quadrant[17]), but in most cases, to solve an intriguing problem ('use-inspired basic research'). Consequently, it is primarily driven at its earlier stages by curiosity and is thus usually investigator-led, although that may evolve in time to mission-led research. It overlaps and has a fuzzy boundary with the other three types of research and is a common thread across the whole of the research and innovation system. Often research funded as knowledge-generating unexpectedly spills over to become highly impactful through either its public utility[18] or seeding the commercialisation path.[19]

110. Knowledge-generating research has multiple purposes, from an improved understanding of some aspect of our world to explaining how this knowledge can be applied in a particular context. Its results are usually published in some form, often after going through a form of quality control, notably peer review. Discovery research also has an important role in training members of the research community and ensuring that tertiary teachers are abreast of the latest ideas in their fields. At a societal level, high-quality discovery research can facilitate national identity and wellbeing, and enhance international reputation.

111. Without ideas flowing from knowledge-generating research and the removal of the intermediate barriers (discussed later), there is no flow of innovative ideas that can be exploited by end users, whether the community, Government or, particularly, the private sector.

112. Currently, New Zealand has several funding mechanisms for discovery and applied research, notably the Marsden Fund, the Endeavour Fund, the Health Research Council, the Centres of Research Excellence (CoRE) Fund and, until recently, the National Science Challenges. In addition, significant research is funded within CRIs via their platforms within MBIE's Strategic Science Investment Fund (SSIF), and by universities, especially through their allocations from the PBRF. The SSIF also supports various ad hoc research platforms and infrastructure, for example, the Antarctic Science Platform and Genomics Aotearoa. The system can be seen as complex, but this complexity has evolved in part because of the need to ensure that a wide range of the creativity of quality investigator-led research is supported and that priority research areas can also be targeted.

Exploitable research

113. The SSAG has used this term to describe research that is directly pertinent to commercial interests and often involves the application of results from discovery and applied research. Some of this research is conducted within the relevant businesses, but some is also done within or alongside PROs or universities depending on its technology readiness level (TRL). TRL levels

17 Pasteur's quadrant is a classification of research according to the answers to two questions: (i) Is the research aimed at a fundamental understanding? and (ii) Is the researcher concerned about the end-use of the results? Respective answers "Yes" and No" correspond to pure, basic research (exemplified by the search for subatomic particles); "No" and "Yes" correspond to pure, applied research (as was carried out by the inventor Thomas Edison); "Yes" and "Yes" is use-inspired basic research (such as that carried out by pioneering microbiologist Louis Pasteur). "No" and "No" is not research.

18 A world-impacting example of the rapid passage from knowledge generation research to major impact was the work of Sir Graham (Mont) Liggins in Auckland, who in the 1960s was doing very fundamental research on the processes of premature labour and made discoveries which within five years revolutionised the prevention of lung disease, the biggest killer of premature babies, and revolutionised neonatal care. Many start-up companies in New Zealand similarly have had their origin in the spillover consequences of research undertaken for knowledge discovery.

19 Study of the basic science of magnetic induction of electricity by Dr John Boys in the University of Auckland Engineering School led to findings which in time, and through passage through start-up company PowerbyProxi, led to a large research enterprise in Auckland as part of the global giant Apple.

1–3 may be encompassed within knowledge-generating research of a more applied nature within the public sector or in large companies within their R&D function. In general, innovators and entrepreneurs seek to invest in research once it reaches higher TRLs, but they may invest early if the market potential is particularly high. Exploitable research is characterised by being 'closer to market' and relies on the novelty inherent in research discoveries (thus generating intellectual property), but also on the ability to see how research can create something useful or marketable. Fostering the appropriate culture for innovation is critical.

114. The role of Government in exploitable research is not passive. Some degree of risk-sharing between the Crown and the private sector is often appropriate, and globally this form of collaboration is the norm. Innovation is acknowledged worldwide as a major driver of economic prosperity, so governments want to encourage such research. Nevertheless, the Government does not want to be seen as subsidising legitimate business costs, for both domestic political and sound economic reasons and to avoid complications with international trade agreements. Traditionally, New Zealand has used a mix of agency support (e.g. NZTE, Callaghan Innovation, NZGCP, seed funds), grants and tax incentives to support this type of activity. Much exploitable research at the low TRL stage has been carried out by CRIs (and universities), who have licensed their findings to industry, although there is criticism that they hold on to it for too long. There are many barriers, both structural and operational, that have inhibited this transition. There is clearly room for a research structure and environment that removes these and more often leads to transformative change, and this is discussed below.

Further comments on this categorisation

115. Much research can serve several of the above purposes, but the above categorisation is useful because it illustrates the broader value of SI&T in a country's development and is more comprehensive than that generally put forward in policy papers and in the political discourse. This approach allows a deeper analysis of the shape of the funding and the provider systems. For example, PROs are more likely to be the mainstay of stewardship research than other parts of the system. It also suggests a greater and more direct role in setting priorities and providing funding for stewardship and public policy research. Similarly, the methodologies and assessment processes needed will vary by class.

116. Another relevant way of characterising research is whether it is disciplinary, or systems based. Most training in research is discipline-focused (e.g. chemistry, biochemistry, anthropology etc.), and this has often extended to how funders and research providers act. But many of the problems we face require interdisciplinary and systems-based approaches. This is most obvious in many of the environmental and social challenges society faces. The need to balance training and recruitment between those with deep disciplinary expertise and those experts in systems approaches will become of greater importance given the nature of problems ahead and the computational tools now available. This too has implications for the organisation of public science and its funding.

117. One theme that is emerging in the global research community and which New Zealand has to some limited extent developed through the National Science Challenges is the concept of *transdisciplinary research*. Here the question and approach are not defined solely by the research community but engage the end-user (be it community, policymaker or business sector) from the outset in a process of dialogue and trust-building from which the research then emerges. Generally, it involves both social and natural sciences. The humanities may also have an important role. It has a particular value in addressing the complex social and

environmental issues that exist. Much research involving both modern science and mātauranga Māori encompasses these methodologies. However, to be successful, the funding instruments, timelines and assessment methods are quite distinct (matters for the next report of the SSAG).

Mātauranga Māori

118. New Zealand is a multicultural society based on its bicultural underpinnings established by the Treaty of Waitangi, which is core to New Zealand's identity. It is essential that the science and innovation system is inclusive and beneficial to the diverse fabric of New Zealand's society. Māori have a particular relationship with the Crown, and the context of this relationship extends to the unique knowledge systems that are inherent to Māori history, identity, values, culture, ancestry and economic wellbeing.

119. There is no debate that research into Māori culture and knowledge is an obligation of the New Zealand research system and that this should be largely determined by experts in mātauranga Māori. We will be recommending a distinct funding stream in the proposed National Research Foundation. Science and mātauranga Māori are distinct ways of knowing.

Diversity

120. Achieving a more equitable, inclusive and diverse SI&T system is critical in creating innovative and impactful research. It is obvious and ethically required that affected populations are consulted for certain types of research, and when transdisciplinary approaches are appropriate, such consultation is absolutely essential. It is recognised that some research has no specific ethnic or cultural considerations, and thus it should be clear that consultation and engagement will be defined by the research question and methodology as appropriate.

The information society and economy

121. It is self-evident that the future requires wise and effective collection and use of data, both to improve stewardship, policymaking and knowledge development and to provide opportunities for innovation. There are many issues. The state of the infrastructure and entities responsible for data analysis (supercomputers, NESI, RIANZ) is concerning. As AI becomes a larger and more critical tool in both Government research and in science-based innovation, greater attention will need to be paid to the digital infrastructure needed. Quantum will add a further layer of complexity and demand. The Future Technology Initiative (FTI) discussed below adds to that need.

122. Stewardship research relies on data collection being valued and data being curated. As the world moves to use data at scale, it is important that data that is interoperable between different types of users. Data policies, including those related to the use of AI, must become a whole-government, whole-society focus. In turn this requires attention to social licence and privacy matters, oversight of government use, etc. New Zealand cannot use research well and apply it in many ways unless outstanding data sovereignty issues are resolved and clear protocols are established, rather than requiring case-by-case addressing. This has inhibited best use of census and IDI data, for example.

Barriers

123. Our consultations and analysis have characterised the New Zealand system as being overly bureaucratic, with compliance costs, barriers, inefficiencies and complexity. Our recommendations address these issues. But beyond these operational barriers there are some higher-level strategic barriers.

124. One clear strategic barrier is the virtual total lack of strategy from the highest level of Government, which needs to recognise the essential toolkit it has in R&D to advance the economy and wellbeing. This has led to a low-funded system with little focus on the long-term, except in flagship programmes such as the National Science Challenges and Centres of Research Excellence (CoREs). Both provide lessons (positive and negative) for future funding tools. If there is no clear strategy, funding agencies can struggle with priority-setting, leading to research that does not meet all the country's needs.

125. New Zealand has had for 40 years an economic mantra claiming it does not prioritise or have an industrial policy – in fact it has and must make choices. We have prioritised primary sector R&D in the past, we have given specific support to the film industry, etc. The mantra claims that 'we do not pick winners', but that's a myth. The two examples of dairy and film show that we have done so in the past, and indeed the whole innovation process depends on 'picking winners and not picking too many losers'. Investors do that all the time, and R&D is a form of investment. We made a choice not to invest in biotechnology 30 years ago; now it appears that choice will be reversed, allowing New Zealand to seek advantage in its biological economy from scientific advances.

126. A core barrier to rapid growth in innovation-led productivity is the lack of multinational corporations (MNCs) undertaking significant R&D in New Zealand.[20] MNCs serve multiple functions in an innovation ecosystem. The reason MNCs are so important is because they have skills and capacity in global market projection, they support and create an ecosystem of local innovative SMEs, and they produce high paying jobs. They are a source of a globally focused entrepreneurial workforce that gradually diffuses into the local ecosystem. Singapore, Israel and Ireland have developed their ecosystems in no small part through MNC attraction.[21] New Zealand has a particular challenge in that it does not have a significant number of local large research-intensive companies – Rocket Lab is an exception and demonstrates how such companies can become the nidus of an innovative and socially important ecosystem.

127. There are many potential barriers to MNCs undertaking research in New Zealand, but no innovation system in the world meets its promise without their presence. Our relatively xenophobic attitude to FDI and what must accompany it to attract staff is a cultural and political barrier. Thus, MNC attraction becomes key – other practical /political barriers would need to be addressed by other parts of the policy sector (immigration, land ownership, FIF taxation regime, etc). The reasons a MNC might locate research activity in a country are largely related to market size and workforce availability, as well as access to an established broader academic and innovation ecosystem. An existing healthy ecosystem stimulates the flow of ideas, which is further enhanced by the presence of key opinion leaders (KOLs). But these attractors do not apply in New Zealand. We have a low proportion of such leaders by global standards in our research system. This is a particular issue that both the SSAG and the UAG both agree must be addressed.

128. As should be clear from other components of this review, we have concluded that a core barrier is the implied or actual incentives that place a focus on universities and CRIs trying to maximise their own value from science and innovation, which is totally different from maximising the value for the invention or product and for the ultimate benefit of New Zealand. This is reflected in excessive expectations for equity and other related approaches, which diminishes the

20 One exception is Apple which, building on science arising out of the University of Auckland, now has its third-largest research centre based in Auckland. This is an example that should be a New Zealand poster child yet appears poorly known, even in our diplomatic community.

21 Bay Area Council Economic Institute. (2024, August). *Growth and transformation: Economic ties between the San Francisco Bay Area and Ireland.*

commercial attractiveness and are unrealistic and outside international norms. We have heard of egregious examples of CRIs holding onto IP to maximise their own interests to the impediment of New Zealand's broader interests. Excessive equity demand by the founding institution is a significant impediment to investor attraction.

129. The lack of a standard approach to the operation of TTOs across universities and CRIs leads to delays and unnecessary legal costs, both of which inhibit start-up activity significantly. The proposed new entity derived from the CRI sector (see below) will in time mean only one TTO will be needed in the PRO sector. Universities and CRIs should have standard TTO rules, as is now the case in some other jurisdictions.
130. There should be the same rights of benefit to inventors irrespective of whether they are PRO or university employees, and this is likely a significant explanation of low deal flow from CRIs as there is a lesser incentive on scientists to identify opportunities. It may have complicated joint pre-commercial activity between universities and CRIs.
131. Overhead rates in universities and CRIs are excessive by global standards, inhibiting companies from contracting research services from the PROs or universities. This is a function of the current funding models for both, plus the incentives on CRIs as Crown-owned companies to make returns and very similar issues in universities. Too much of the competition between the institutional players in New Zealand is driven by competition to receive these overheads. While it is beyond this first stage of either review, other countries can provide lessons on how this issue can be addressed, much related to the overall funding models in play.
132. These issues lead to both lower deal flow and costly barriers impeding innovation flowing to the private sector. Given that the early stage of the innovation sector's growth depends on the volume of deal flow, these are priority issues that could be addressed through shareholder instructions to the CRIs and through the contracting processes in the university sector.
133. A further issue is the scientific culture, especially in universities, but also in CRIs, that values public good research disproportionately over research of commercial value, and in universities values basic research with higher prestige than applied research. These are the issue that different human-centred research policies need to address, including promotion, tenure and the attitudes of scientific bodies.
134. The training of research graduates needs to include entrepreneurship and exposure to the private sector. Only a minority of PhD graduates can anticipate a career in academia, yet their training is largely designed for academic careers. The expanded use of industrial PhD programmes is highly desirable. This issue will be addressed in the UAG report.
135. Until STEM education is improved in high schools, the flow of ambitious and a more diverse cadre of students to SI&T will not be what it should be. It is unfortunate that the country appears somewhat complacent to this issue, and it was disappointing that MBIE reduced its small investment in such activity in 2023.
136. The precarity of research funding, especially at early stages in research careers, leads to some of the most promising researchers seeking horizons offshore. These issues will be picked up in the subsequent report and that of the UAG.

A Future-Facing Architecture

137. The above commentary and the Cabinet paper have led the SSAG to focus in this first stage of the review on what should be the shape of the overall system's architecture. Minor tinkering with the system cannot meet the objectives of the Crown, and we conclude that a substantive overhaul, the first since 1991, is desirable. The architecture must not only meet current needs but must also be one that is fit for the future – one that will suit coming decades and will need new elements as well as reshaping of the old. It should not be driven by partisan ideology. We recognise that the changes suggested are substantive, but they can be implemented in stages and can be done with care so as not to disrupt a rather fragile system. While there will be efficiencies gained both in process (e.g. TTO rules, integrating support functions across the public research sector reducing unnecessary duplication), our focus has been on the strategic role of SI&T effectiveness and producing a system that will allow New Zealand to sustain and enhance its position as a small, advanced economy.

Prime Minister's Science Technology and Innovation Advisory Council (PMSTIAC)

138. One of the current Government's five key economic strategies is to exploit the research and innovation system. But the system has much broader roles to play in terms of national wellbeing, and in stewardship of the nation's physical, environmental, social and human assets. SI&T is important for better policy formulation, evaluation and implementation; in defence, diplomatic and strategic matters; in ensuring that knowledge generation plays its key role in all aspects of New Zealand society; and contributes applicable knowledge to government, communities and to the policy sector. Indeed, there is not one aspect of government policymaking where science (broadly defined) does not have a critical role to play.

139. Science and innovation cannot therefore be left solely to a single ministry. Many governments have recognised that and have ensured a whole-of-government, whole-economy, whole-of-society approach by establishing a Prime Minister's Science, Technology and Innovation Advisory Council (PMSTIAC). These include the UK, USA, Japan and many European countries (although they may have a variety of names).

140. The primary function of the PMSTIAC might be to:

    a. Assist the Government in ensuring long-term direction and high-level priorities for New Zealand's science, innovation, technology and higher education system.

    b. Ensure a more integrated, whole-of-government approach to science, innovation, technology and its use.

    c. Monitor the execution of science, innovation and technology strategy and priorities.

141. The PMSTIAC's advice could be used to inform:

    a. Government's budget strategy for science, innovation, technology and higher education.

    b. Science, innovation, technology and higher education system strategy and policies.

    c. Funding strategies developed and deployed across Government funders of science, innovation, technology and higher education both within and beyond the Ministry for Research, Science and Technology.

    d. Reviews of system performance.

142. The Council will be convened and chaired by the Prime Minister and include the following core members:
    a. The Minister for Science, Innovation, and Technology (Deputy Chair).
    b. The Minister of Finance.
    c. Prime Minister's Chief Science Advisor (PMCSA), who shall act as the Council's executive officer.
    d. Distinguished New Zealand scientists who are not institutional leaders, and individuals from the innovation sector and business. These core members will bring diverse expertise in science, technology and innovation. International membership may be valuable, and Māori membership would be important.
    e. Other Ministers invited by the Prime Minister as appropriate for the agenda (for example, Economic Development, Foreign Affairs and Trade).
143. The PMSTIAC would be supported by the Prime Minister's Chief Science Advisor (PMCSA) and the Office of the PMCSA acting as the secretariat.

The PMCSA

144. The Prime Minister's Chief Science Advisor (PMCSA) has been an established role in New Zealand since 2009. The primary focus of the role has been to provide robust advice to the Prime Minister on scientific matters and to be a conduit between the science community, Government and society.
145. The job description for the current role would require revision to encompass the role of the executive officer of the PMSTIAC. This dual role as PMCSA and executive office to a body such as PMSTIAC is like that of the other nations such as the USA and UK. The role of the PMCSA in supporting the PMSTIAC is strategic in nature, requiring the ability to guide the Council on leveraging science to navigate the complexity of matters for improved decision-making across Government for economic and social prosperity. Traditional responsibilities such as assisting the Government during emergencies and ensuring the use of evidence in policy formation are also integral to the role. The role also involves aiding the Prime Minister in propelling New Zealand forward through science and innovation diplomacy.
146. Supported by the DSA mechanism (which also requires attention and standardisation of their roles and responsibilities), the PMCSA is crucial to ensure issues across Government are informed by better policymaking and investment decisions. The application of research within departments and government entities is currently inconsistent and highly variable, despite the clear necessity for its use in fostering improved stewardship and policy formation. Currently the departmental science advisory system is very variable and generally not meeting the function of ensuring quality in evidence-informed policy development and departmental use of data, knowledge and research. This deficiency can be attributed, in part, to the absence of a uniform job description and a clear determination of where such roles are justified within the system. A review of the DSA system may be needed to address these issues, and the SSAG anticipates revisiting this topic in its second report.

An integrated and focused ministry

147. Internationally, many countries have put the total knowledge generation and application system into a single policy ministry. In New Zealand we have not done that, with MBIE covering research, science, technology and innovation, and the Ministry of Education covering universities, yet

universities are the largest component of the public research system, the primary generators of the trained workforce, and have key roles in transmitting knowledge to public, policymakers and business. Unlike CRIs they encompass the whole span of knowledge disciplines.

148. As the UAG has already advised to the SSAG, the university system is remarkably devoid of strategic oversight, leading to many issues including the failure to consider the value of greater differentiation and collaboration. The UAG further advises that in the current arrangement, this strategic void is unlikely to change soon. Thus, the need for seamless strategic integration and linkages between these two components of the SI&T system is seen as a priority. As an effective SI&T system must have a smooth interface between all components of the public research system, a singular policy approach is required.

149. There are several options. Arguably the most straightforward, as is done in many other countries, including most of Europe and Japan, is that the university component of Education is moved to sit alongside research and innovation in a new ministry. At a later stage, the Government might decide whether vocational training (polytechnics, etc.) remain in Education or move to this new ministry. This recommendation has been discussed with the parallel universities review (UAG) and is endorsed by them. The rationale for the merger is discussed at multiple places in this report, but the issue is highlighted by the barriers that exist unnecessarily between these two components of the public research system.

150. The name of the ministry should be resolved once a decision is made regarding the placement of higher education.

151. A core role of the ministry should be to establish priorities and roadmaps (in conjunction with other ministries and PMSTIAC), to coordinate national needs in knowledge and workforce, and to provide common foresight to the whole system as to future needs for New Zealand and the rapid transitions underway primarily based on technologies.

152. The ministry should contain a foresight, data and intelligence unit aggregating data, exploring trends and making international comparisons to support both its policy development and performance of the system.

153. The proposed ministry would operate through four vehicles:

    a. A National Research Council

    b. An Innovation Advisory Committee

    c. A Higher Education Council[22]

    d. A Research Infrastructure Advisory Committee

    The membership of these four vehicles would be individuals with appropriate expertise and mana from within both the public and private sectors, and there should be cross representation across these vehicles. These vehicles will be considered in more detail in the second report, following decisions by Cabinet arising from this report.

A National Research Council (NRC)

154. New Zealand has a plethora of funding mechanisms operated through three primary agencies: MBIE, the Health Research Council (reporting jointly to the Ministers of Health and of SI&T) and the Marsden Fund (subcontracted from MBIE), as well as several ministry-operated funds, the latter with a mix of formal and informal processes. They overlap in scope and are each relatively small by global standards and use a variety of application and assessment techniques. They

22 Or be linked to it if the arrangement of ministries is different to that which the panel favours.

have a high cost in terms of high application-to-success ratio (reflecting funding available), much higher than in other countries, and the costs to New Zealand Inc. are very high. The differing application and assessment processes are problematic. Further, as there is no strategic integration between these funding agencies, there can be duplication of effort, a failure to meet needs (especially in some domains), and much of the funded work is subscale or too short-term, creating its own inefficiencies and workforce issues.

155. Current funding models do not distinguish well between the four classes of research described above, and they discount, for example, investment in some aspects of stewardship research. While these issues will be dissected more in the next report, it seems obvious, and has been paralleled in other jurisdictions, that a single funding agency would assist, albeit with distinct allocation expert panels across different domains of research, which must ensure research that extends from primarily being driven by intellectual impact to direct application which we refer to as pillars.

156. Likely pillars might include clinical science and public health, biomedical and life science, agricultural and environmental sciences, natural sciences, digital and related science and technology, social sciences, humanities and creative arts. There is strong agreement that a Māori-led panel for mātauranga Māori research is needed, and that too would fit in that structure as a further pillar. All would include research across Pasteur's quadrant. Different domains would use a toolkit appropriate for both the type of research and the likely end user community.

157. The current use of peer review and indeed the criteria for grant award merits reflection (see Priority section below). In the case of peer review, in a small country there are many challenges. Initiatives overseas are aiming to achieve more effective, efficient and less burdensome processes, especially for the applicant, where much hidden cost lies. This will be a focus on our next report, but the critical mass of a single funding agency should improve thinking and actions in this problematic area.

158. Internationally it is recognised that research systems can disadvantage intellectually high-risk research from which some disruptive innovation can occur. Increasingly they have created distinct mechanisms to identify and ensure such research. This will be discussed in the next report.

159. Further consultation is needed before this recommendation is acted upon and will be discussed further in the second report.

A Higher Education Council (HEC)

160. The university sector is collectively forecasting a deficit for the first time on the TEC record, for the 2024 financial year. This situation, along with the issues discussed above that face the broader SI&T sector and the lack of effective strategic oversight, presents an opportunity to consider how to address longer-term challenges for higher education, particularly universities, as an inherent component of the science, innovation and technology system.

161. The UAG is currently discussing the merits and functions of a possible Higher Education Council, and particularly a role in providing strategic oversight for the sector, a development we would strongly support.

A Research Infrastructure Advisory Committee (RIAC)

162. Cutting-edge research needs access to often expensive infrastructure. But the decision over what is needed, where it should be situated and who should manage it needs to be strategically overseen. It seems logical and efficient that a research infrastructure advisory committee

advising the Ministry is established to provide input from the NRF and NIAC, universities and the PRONZ, and taking technology foresight into account, to advise the Ministry on policy and funding decisions on major research infrastructure (say > $0.5 million).

163. There are significant infrastructure deficits in life sciences and particularly in the types of big data and computational facilities needed. Further, much infrastructure in universities and CRIs is duplicated but underutilised. Access for other users such as the private sector is often difficult. The need to build business cases for purchase of large-scale innovative equipment can be complex given that for discovery research, the end user is not obvious. This is further compounded by depreciation rules that assume the same institution will own the replacement device, which will be of the same order of magnitude of cost. This is clearly not the case with most high-end scientific equipment. The high-cost computer of two decades ago is now a desktop computer; the expensive gene sequencer of 2000 is now a fee-for-service activity. This Treasury-imposed arrangement is globally unusual and has inhibited some advanced equipment purchase over the past two decades.

164. It is suggested a more system-wide approach to providing high-cost research equipment (say valued at > $1million) and dedicated research infrastructure (e.g. a biohazard containment facility) across universities and CRIs is needed. Where appropriate, this could include access agreements for the private sector. If the Crown, via the NIAC, supports high-cost testing equipment and facilities in incubators or accelerators operated in the private sector, the reverse arrangement could be put in place.

165. Research vessels such as Tangaroa and the investment in supercomputers or quantum computers clearly need individual consideration through such a mechanism.

166. A national platform to support e-Research capabilities is needed. Over the last decade, CRIs and universities have collaborated on the provision of high-performance computers, research data management, training and connectivity. These capabilities underpin New Zealand's aspirations, across not just AI, but virtually all research domains. It is an area that lends itself to economies of scale and scope. Until now the capabilities have been supported through two separate vehicles: the New Zealand Science Infrastructure (NeSI) to the Research Education Advanced Network New Zealand (REANNZ). Currently MBIE is considering combining these two vehicles into one to grow the uptake and level of sophistication of digitally enabled research in New Zealand. This seems a logical step, but it will need to liaise closely with the Futures Technology Initiative if it is established.

A National Innovation Advisory Committee (NIAC)

167. A major goal of the research and innovation system is to drive productivity, and there are many components to an effective research-based innovation system. It must be dynamic and responsive, minimise barriers, take risk and share the risk appropriately between the Crown and the investment community. It must be capable of managing different types of innovation that require different support mechanisms (e.g. the pathways for software, agritech, foodtech, medtech, pharma, fintech, cleantech and industrial tech development are all very different). Thus, there must be adaptable and responsive mechanisms, and decisions must be informed and made by relevant experts rather than by generic advisors. We suggest that this is best done by an expert advisory committee informing policy development by the Ministry, to ensure a more seamless system in which investors and entrepreneurs can access the right people, the right advice and the appropriate support at the right time. Start-up and scale-up of domestic companies is very different to attracting MNCs and capital from offshore. The latter requires

distinctive attributes and skills to achieve effective matchmaking and to respond to investor enquiries at different scales.

168. While different parts of the private sector have different interests in the innovation chain, there is a broad theme coming from our consultations and submissions which strongly supports the SSAG's view that the current setup, comprising elements of pre-seed and seed funds, grants, Callaghan Innovation, incubators, NZTE and NZGCP as major components, is not working well as a system and needs to be fundamentally rebuilt. Innovators need a system that is easy to navigate, as barrier-free as possible, and knowledgeable. The primary role of the National Innovation Advisory Committee (NIAC) and Ministry would be to ensure a better coordination and allocation of activity across these various rebuilt components, recognising that different types of innovation merit different pathways of development and public risk-sharing and assistance.

169. While the innovation pathway would be operated through two agencies discussed below, INZ and ENZ, the overall sector would be coordinated through NIAC.[23] NIAC would be chaired by a well-established and recognised expert at innovation (likely a member of PMSTIAC), the chair and CEO of INZ, a member of the boards of NZTE and NZGCP, and several established experts in scale-up, start-up and MNC/capital attraction. It may be that some of these should be international members, given the state of the system and to reduce conflicts of interest. NIAC's primary role would be to advise the new Ministry on policy settings and opportunities, and to ensure barriers are reduced where possible.

Enterprise New Zealand (ENZ)

170. The focus of ENZ should be on the start-up and scale-up of New Zealand-born companies. It would encompass coordination and, where appropriate, the activities now spread over several components of the system: seed funds, tech incubators, grants, mentorship, etc. It would be a single point of entry for all innovation companies seeking assistance, either financial or otherwise. It would need to link closely with INZ and with other components of the system.

Innovation New Zealand (INZ)

171. We propose that a stand-alone innovation agency, INZ, is established, with leadership provided by credible innovation expertise from the private sector. The agency would have the following functions:

    a. Attracting Multinational Corporations (MNCs) to establish R&D in New Zealand.

    b. Matching MNCs with New Zealand entities.

    c. Attracting venture capital and FDI from overseas into the innovation economy.

    d. Assisting New Zealand companies at the appropriate stage to go global.

    e. Coordinating with NZTE, MFAT and other ministries where opportunities are identified.

    Some of its initial staffing would be derived from Callaghan Innovation and from NZTE, but it needs additional skills to support functions that are currently not fully provided.

172. The SSAG has considered alternative structures, including merging all or some of the proposed activities into NZTE or having a single entity encompassing innovation and enterprise activities.

23 The panel considered whether INZ and ENZ could be a single entity which would mean that NIAC could alternatively be the entity providing those services between two separate divisions. But there was much advice both domestically and internationally that the predevelopment of New Zealand companies through scale-up and start-up required a very different focus to that of inward attraction of major investments and MNC and that the types of boards and management needed were significantly different that they were best separate entities.

But NZTE is not an appropriate organisation to support start-up and scale-up activities, and in general outward-facing trade-related activities do not sit easily alongside inward-facing company and investment attraction (albeit that NZTE currently has some such activity in terms of venture capital attraction). After consultation, the SSAG thinks the focus and skillsets required for inward attraction of MNC research activity and innovation-related FDI are distinct enough from scale-up and start-up development to require different skills in leadership and operation.

Implications for current components of the innovation system

173. Callaghan Innovation has had its challenges, and it has become apparent that it is not well equipped to meet New Zealand's future-focused needs. The concept of merging a research and service unit (IRL) with an innovation agency function may have been flawed at the outset and created management problems and distrust with the sector given the perceived internal conflicts of interest. There is wide agreement that in its innovation function, beyond providing grants in aid to start-up companies, it has not been a great success. In its research and development role, its performance has also been mixed.

174. The SSAG does not believe minor modification can be effective. Callaghan Innovation itself acknowledges that its innovation function has not been a success – and it has not developed core roles of attracting major investors, MNCs and capital that an effective innovation agency should have. Furthermore, the combined functions have led to the resources intended for support and innovation being used to cross-subsidise the research service function.

175. Some assets of value have already been spun to Victoria University, leaving a set of industrial support functions that are apparently not viable because of limited demand. Nevertheless, there are important units within Callaghan Innovation that could sit well within a combined singular PRONZ (e.g. the metrology unit). The remaining industry support functions need to be assessed. Consultation with early-stage companies (both public and private) might identify some core needs that should be provided as shared or hireable infrastructure. But an assessment of the landscape suggests there are alternate private sector or public sector hosts.

176. At a smaller scale, the New Zealand Product Accelerator (NZPA) provides matching services between technical providers and the private sector to meet their demand without sustaining a raft of poorly used services, and it is supported by a relatively small public sector grant. This suggests new models can be developed that are more effective.

177. The Gracefield site is expensive to maintain, degraded and not attractive to many clients because of its state and location. There are many legacy issues to the site that are expensive, and continued investment to maintain a substandard site seems unwise.

178. Some components of NZTE offer some support to companies seeking offshore venture capital, but in general innovation agencies and trade agencies are dealing with very different client sets. While some of the efforts through NZTE suggest a commitment to providing the missing innovation services, its core function is assisting the normal business of promoting export trade from established New Zealand companies. Supporting start-up, scale-up, MNC attraction, capital attraction and partnerships are very different activities requiring different expertise. The offshore platform of NZTE is not designed or staffed appropriately to meet the needs of scale-up, MNC attraction and investment attraction. Other countries clearly distinguish innovation agency functions from those of trade promotion.

179. There are some purely private sector-operated incubators owned by venture-focused firms (e.g. Outlook Ventures which serves deep industrial technology) and others supported by Callaghan

Innovation on a model derived from that used in other countries. Views on their effectiveness vary, reflecting the different outcomes of investment choices made and stakeholder interests. The different views relate in part to the quality of services provided (e.g. mentorship) and the way financial support is provided and compensated for (equity, redeemable contingent loans, etc).

180. The growth of the angel investor community and venture capital activity in the last decade is palpable. The importance of seed funds offered through TTOs, KiwiNet and Callaghan Innovation is important. This requires more analysis, along with consideration of NZPA, NZGCP and other parts of the broader ecosystem, which is beyond this interim report.

181. NZGCP and its Elevate fund (a fund that operates through providing funding from the NZ Super Fund to venture funds) receives much positive comment. At this stage, we would suggest it continues as at present as it has a particular skill set. But at an appropriate future time, depending on whether Elevate is extended and added to by other funds or not, it may be better placed as a subsidiary of ENZ and Aspire as a component of INZ.

Future Technology Initiative (FTI)

182. Competitive economies overseas rely on innovation as a driver of economic growth and focus on global economic competitiveness. Looking forward it is clear that to be successful economically in a technological age, a country must have research capability for advanced technologies in a country's national innovation system.

183. New Zealand must be realistic. It has been very late to enter the market of innovation based on advanced technologies. It must also be pragmatic; it has neither the human nor fiscal resources to pretend that it competes in the basic discovery and development science of such technologies. Rather, it must play to its strengths of application, exploit data niches and build a distinct approach that's ambitious but appropriate for a small country.

    The proposed Future Technology Initiative (FTI) is suggested as a virtual platform to bring together Government, business and academia so that all aspects of the innovation ecosystem are operating cohesively and with a common purpose. It is also a mechanism through which there is alignment of funding initiatives, infrastructure and critical assets, processes and governance. It will require a common and centralised backbone that provides the physical infrastructure, digital and data capability that is needed to support data-intensive and complex initiatives.

184. The core business of the FTI will be promoting emerging technologies including AI, quantum and synthetic biology. Using that lens, it will have several pillars that are focused on individual technology areas with a distinct New Zealand lens and value proposition, and where we envisage competitive advantage. R&D funds linked to the FTI would be ring-fenced but distributed through the NRF or ENZ. There can be any number of these pillars, but each pillar must have a credible competitive advantage and market direction and can be staged between wholly or partially state funded and the private sector. These would undertake the R&D to develop applications capable of being taken to market.

185. The FTI would also have core enabling functions including:

    a. Liaising with the proposed Higher Education Council on training needs.

    b. Capacity building and outreach functions (diffusion and capacity building in companies) needed to act as an interface to help businesses and other key user groups use advanced technologies and developments effectively.

    c. Development and training to support government officials, practitioners and key decision makers.

d. Technology foresight, assessment and application using advanced practices and methodology.

e. Advice on the economic, social, intelligence and security dimensions. Given the nature of some aspects of advanced technology, national security sensitivities will need to be appropriately considered within the FTI.

186. The FTI would be overseen by an appropriate expert committee, potentially with international members advising the Ministry where resources assigned to the initiative might be allocated via the NRF, HEC or ENZ. It would have close liaison with the NIAC. Some functions such as training or technology assessment might be issued by a Request for Proposal (RFP) to third-party providers.

187. A putative model of the FTI is shown in figure 6 below, but consultation is yet to be completed. DP1–4 are distinct developmental pillars – e.g. Medtech, etc.

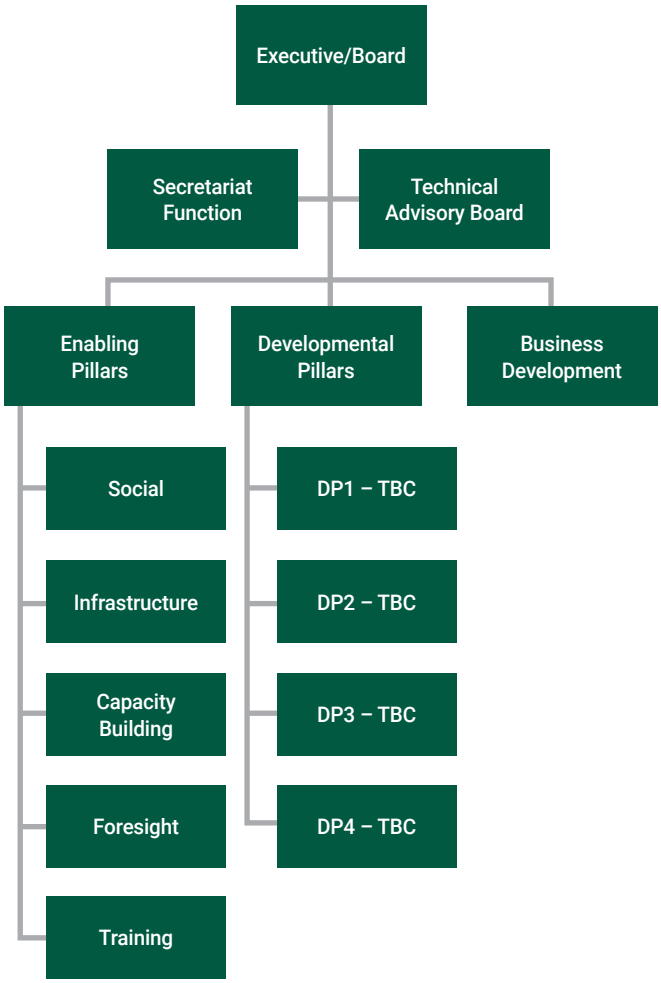

Figure 5: A putative model of the FTI.

Current public SI&T providers

188. The bulk of publicly funded and orientated research (stewardship research, research for policy development, research for knowledge development) is provided by the CRIs, universities and some independent research organisations such as Cawthron Institute. Exploitable research may arise in all these sources or directly in the private sector.

189. As is discussed elsewhere in this report, significant issues and barriers exist in the undertaking of research, and the system for undertaking publicly funded research needs to be fundamentally addressed if New Zealand is going to get the productivity and economic gains possible from such research.

Universities

190. There has been considerable interaction with the UAG, and there are no disagreements on the critical roles of the universities, namely emphasising that universities are major providers of public-good, funded research & development covering all the four types of research discussed above, but particularly leading on knowledge-generating research, while contributing to both stewardship research and increasingly to policy-focused research and exploitable research.

191. There are many issues in the university sector that are for consideration by the UAG. Core to our review is the concerning lack of strategic oversight of the university sector and secondly a set of issues similar to those in the CRI sector related to incentives and barriers. Both the UAG and SSAG believe that it is critical that the barriers between the university and CRI sectors are reduced. Many of these relate to the strongly institutionally focused incentives; significant change is needed in how technology transfer is managed. If the recommendation below regarding the future of CRIs is accepted, then the potential for much more effective hub-and-spoke relationships between the PRO and university sector are possible, allowing even more novel partnerships, including the private sector, to evolve. In the next phase of the review when we consider funding models, the importance of large-scale, long-term flagship initiatives that span these organisations constructively with less bureaucratic interference will be discussed. The potential for greater interchange of staff and students becomes obvious.

Public Research Organisations (PROs)

192. There are several research entities wholly owned by the Crown. The most obvious components are the CRIs and a portion of Callaghan Innovation (ex IRL). Others include the MetService, Defence Science & Technology, and Antarctica New Zealand (primarily as logistics supporter but hosting a research platform). New Zealand is distinct in that such a high proportion of publicly funded research expenditure is via PROs – this is both a function of the Crown's ownership interest and the overall low total spend on R&D.[24]

193. The CRIs were established in 1991 as Crown-owned companies expected to act commercially and make a financial return on investment to the Crown, even though a large focus of what they do is stewardship and policy-related research. The level of shareholder interest in their missions and role is minimal and over time has largely related only to financial monitoring, allowing mission creep, duplication and gaps to appear. There is no overall strategy for the science sector and for the CRIs, and the commercial incentive drives a lot of undesirable consequences. Because of their structure, the system has not evolved, and 30 years on from their introduction, the shape of the sector remains largely primary sector and environmentally focused. Advanced technologies have not been strategically developed as a focus.

194. The ownership interest, which is distinct from that of universities (which are not Crown companies) has favoured decision-making by MBIE. Some of their decisions are not based on scientific need but rather on the need some CRIs have faced for additional financial support which has then been provided via another MBIE fund, the strategic science investment fund (SSIF). Some CRIs have close relationships to the private sector (e.g. Scion, Plant & Food) but

24 For example, the expenditure on agriculturally focused research is disproportionately high in fractional terms, but if adjusted to the level that other OECD comparator countries spend on publicly funded R&D it would be at about the OECD average.

the question of whether they might crowd out private sector investment (e.g. AgResearch and the dairy sector) must be repeatedly asked. The role of the levy-based system from primary producers has weakened, due in part to past decisions of governments shifting the focus of industry-based levy bodies away from a focus on science, and perhaps also suggesting that the contributions of the CRIs to some sectors' industry may be less convincing than in past decades.

195. The financial state of the CRIs is concerning, and many have very high capital and core operating costs. In 2020 the CRIs were reviewed in detail in a report entitled *Te Pae Kahurangi*. That extensive report pointed to many issues, and while the authors of that report would have liked to recommend restructuring, they felt constrained from doing so. We have interviewed the chair and have representation from that review on the SSAG. The logic contained in that extensive report showed the need for restructuring is compelling and need not be repeated here.

196. The PRO system is inefficient, with several CRIs competing (but responding to current incentives) for the same research. This overlap is nonsensical given each should have a clear focus. For example, two CRIs (NIWA, GNS) have run underwater autonomous vehicles, at least two are engaged in aquaculture (along with Cawthron), many are involved in freshwater research, etc. We have been told of CRIs holding onto IP rather than releasing it where it could be exploited because they see their own commercial model being the goal rather than national interest – again, a logical response to the corporate model.

197. The CRIs have seven independent boards and a lobby group (Science New Zealand). They are not required to consult or coordinate, and no sharing of back office or support functions occurs. Yet by global and domestic university standards they are small research organisations. Most importantly, the lack of strategically driven ownership means they have undergone mission creep. Overall, they are no longer well-matched to or appropriate to meet New Zealand's needs, even though some have good client relationships.

198. The SSAG has considered several models, from no change to partial mergers to complete merger to merger with universities (as was done by Denmark) and looked extensively at international models. Partial mergers would leave the same set of problems at the boundaries that we have been charged with trying to resolve, and would offer no advantage. While no model can be uplifted in its entirety from elsewhere, arguably the most insightful model comes from Singapore's Agency for Science, Technology and Research (A*STAR), where a single board operates several service platforms and several distinct scientific pillars currently termed institutes. Each institute is scientifically led and responsible for agreed deliverables to the headquarters and board. These are increasingly plastic being reshaped, when necessary, with scientists moving between them, to ensure capabilities match strategic need. There is strong scientific oversight, but with the board having the capacity to amend and reshape institutes and platforms, and reserving funds for cross-institute initiatives or to open new areas of enquiry which in time may become a formal group. They give considerable attention to workforce development both on their own and with the research universities. It has a high global presence both in research and innovation because of its critical mass. A*STAR undertakes all four classes of research, often with close relationships with academia (with many joint appointments), the public sector, and especially with the private sector. Each unit remains focused on its mission through mission-led research, contestable research and contract research. There are mechanisms to avoid unnecessary duplication, just one back office and a single set of administrative rules across the whole of A*STAR.

199. We recommend using the desirable characteristics of A*STAR as a model that can be modified to meet New Zealand's needs by forming a new and distinct public research entity (provisionally called in the report Public Research Organisation New Zealand, PRONZ). This unitary model avoids the disadvantages of the current approach, creates efficiency and quality, avoids duplication, promotes adaptability by rearranging science groups, and would allow over time (subject to comments below) a hub-and-spoke model to be developed with co-located universities, addressing issues of workforce development, critical mass, career satisfaction and clarity for the private sector.

200. We recognise that such a major reorganisation of the public research sector as proposed needs careful planning, driven by the strategic needs for science and innovation to support New Zealand's future. This cannot be done overnight – indeed, recent history highlights the need for a carefully staged approach. The end state is clear, but it might best be progressed by first appointing an appropriate board experienced in change management and a CEO supported by strong science advisory group. Initially, they would develop a strategy and reduce inefficient duplication, then focus on building synergies and in time, this would lead to a single adaptive entity. The current CRI boards might be replaced by this newly established board and transition the roles of the existing CRI CEOs to executive director of business units focused on priority science needs. The sector needs changes in funding mechanisms to reduce overhead costs and address misplaced incentives. These will be discussed in the next report.

201. The pillars of PRONZ may be a mix of service units (e.g. Callaghan Innovation's Measurement Standards Laboratory) or evolving domain pillars from the current CRIs. Over time these pillars may undergo change to ensure the needed capability groupings, but this would be driven strategically by its board in consultation with the Ministry. The overlapping MetService and NIWA functions should be combined. The future of ESR should be considered separately or in due course, and its primary function is to support the Ministry of Health and provide forensic services.

202. Many of the issues CRIs should be addressing in stewardship and policy-focused research require systems approaches. Often these will require integration across CRIs and other actors. An integrated model would reduce the difficulties such research currently faces.

203. The board of PRONZ should be chaired by someone with deep experience in public science policy, science strategy and governance. Board members should include distinguished academics and business leaders who understand the R&D science, and it should be supported by a strong scientific advisory board and be informed by the Ministry's strategic oversight. Each unit should be managed by scientific leaders with a singular set of back-office functions. Governance must ensure unnecessary duplication is avoided and that barriers between the units and between the new entity, business and universities are minimised.

204. The legal model for PRONZ is for officials to advise – it may be that the Crown-owned company model is not ideal, and a Crown entity may be better to reduce issues of value capture that exist in the current model.

205. During our consultations, many other matters regarding CRIs were identified. Some of these are discussed elsewhere in this report – for example, it is inconsistent as to whether CRI staff can benefit from their own discoveries and inventions (unlike university staff), and in general there are a lack of processes and policies that encourage commercialisation processes (also true of universities). The new public research entity would allow the formation of a single technology transfer organisation to support it. Given concerns as to the skills set available to promote technology transfer, gaining critical mass would be important.

206. One comment received from officials during the review process merits confronting and correcting. Given the free market nature of the New Zealand economy, some officials were concerned that the changes recommended would reduce competition and therefore must be bad. These are erroneous concerns on several grounds:

    a. The overly competitive nature of New Zealand's funding system has disadvantaged innovative and intellectually risky research, and yet it is that class of research from which most innovation arises.

    b. Merging the CRIs in 2 or 3 entities as the final outcome would not address the core issues that we have considered although they may provide some intermediate staging.

    c. By definition, the CRIs should have been focused on distinct fields rather than competing, and where interests overlap, they should be collaborating.

    d. The nature of scientific egos is such that the major reward is respect from their peers, which itself encourages high-quality research.

    e. There is much evidence that institutional arrangements have inhibited the needed collaboration.

    f. The Cabinet paper that established this review pointed to the need for greater efficiency and less duplication, much of which has arisen from the current institutional arrangements in which boards and CEOs have responded appropriately to the incentives in play.

    g. Being a small country, strategic collaboration is necessary both between research providers, and between them and the policy and private sectors, to create critical mass.

Independent research institutions and other research providers

207. There are several independent research organisations, all of which have a clear focus and some of which play a key role in supporting New Zealand's interests and remain critically important into the future. Cawthron Institute, for example, plays a key role in our aquaculture and marine science effort, Malaghan Institute of Medical Research is one of several medically focused units and is showing valuable innovation in therapeutic developments especially in cancer, BRANZ provides for research related to the building sector, etc. To the extent they are independent, they nearly all rely on the Crown, primarily through competitive funding. In some cases, the Crown has given them some baseline support through the SSIF. The Ministry and NRF would need to review such support on an ongoing basis, making certain they are avoiding unnecessary duplication but ensuring diversity and opportunity in research provision, especially in the more applied and innovation-focused areas of research. Funding issues will be addressed in our later report, but it is recognised that independent research organisations can create significant leverage off Government investment.

Other Government SI&T entities

208. Many government agencies support research directly. This research may be carried out through their own staff (e.g. DOC), by contract to other research providers (e.g. MPI) or by consultants. Much of this contracting goes to CRIs or universities. Some may be of significant scale and in some cases in partnership with the private sector (e.g. AgriZero). Research is also supported for other purposes – MFAT funds research in the Pacific and Southeast Asia as part of aid programmes or in its support of Antarctica New Zealand; Defence funds research primarily through Defence Science and Technology (DST). Operational research is necessary in the service-focused ministries such as Health, but in general this activity is at a much lower scale

and less formally organised in many agencies than might be expected compared to other jurisdictions or to the private sector. The proposed architectural changes will address several concerns that ministries have raised about contracting to CRIs and universities.

209. Data is key to policymaking. The census, the Integrated Data Infrastructure (IDI) and the role of the Social Wellbeing Agency and ministries such as statistics are key. But many issues remain poorly addressed regarding data oversight, issues such as data sovereignty must be resolved, and continual modification in the light of new technologies such as AI mean a whole-of-government approach is needed.

210. But as is highlighted elsewhere in this report, quality control of problem definition, methodology, provider, reporting and uptake is key – resolving these issues may be a key role of the DSA system. This will be further discussed in the second report.

Technology Transfer Organisations (TTO)

211. Much exploitable research originates in universities or PROs. But to be exploited, in most cases it must leave the university or CRI in the form of IP, a spinout company or staff migrating to the private sector with the IP and know-how. Extensive feedback suggests that the public-private interface is one of the most problematic issues for the New Zealand innovation system and one where rapid change is possible. These functions are managed by the technology transfer organisations/offices (TTO) of the CRIs and universities. With the arguable exception of UniServices, none are of scale and all work to support the interests of the institution that owns them rather than maximising the value to New Zealand of the product or idea. Some of the issues raised include:

    a. Cultural gaps between the academic and industrial worlds.
    b. Limited understanding of entrepreneurship by academics and researchers.
    c. A lack of processes and policies (e.g. training on innovation and entrepreneurship, promotion, entitlements) that encourage commercialisation processes.
    d. A general lack of understanding of the need to promote the invention to its own benefit and that of New Zealand rather than the needs and interests of the academic institution.
    e. No discernible standard or set of norms surrounding intellectual property (IP) ownership rights at New Zealand universities and CRIs.
    f. IP ownership policies at some New Zealand universities are either underdeveloped or unenforced, complicating the commercialisation of discoveries.
    g. New Zealand TTOs are under-trained to perform their role in the ecosystem.
    h. Many TTOs lack full awareness of research projects with commercial potential within their own institutions.
    i. TTOs lack the methodologies and authority needed to guide researchers to protect IP prior to publication.
    j. TTOs are excessively protectionist when approaching collaborations with commercialisation partners such as technology incubators, venture capital (VC), and corporate venture capital (CVC).
    k. TTOs may leave commercialisable research on the shelf, ignoring the limited ‘shelf life’ of commercialisable IP.
    l. Conservative views of research staff regarding intellectual property use rights.

m. Gaps in knowledge and professional understanding of commercialisation unit teams in various academic institutions concerning legal, operational, business and industrial issues related to the commercialisation process.

212. The naive idea persists in the New Zealand ecosystem that exploitation of IP is how PROs and universities could generate significant income – this is just not the case globally. There are very few exceptions internationally, and most of those have been based on one or two mega-deals paying royalties in the highest ranked universities.

213. Matters are compounded by slow legal processes, unrealistic valuations and equity retention (which in the case of start-ups can effectively destroy the company when the institution retains a large share and yet is a passive investor), which diminishes the founder's reward and thus investor interest, especially given the inevitable effects of dilution. Overseas, several jurisdictions are demanding a singular approach to TTO conduct across the public sector – applying standard rules under which a TTO operates, thus limiting equity retention etc. Indeed, in Canada, some institutions (e.g. Waterloo University) do not claim any equity at all, leaving exploitation in the hands of the inventors, and this has proved very successful. Royalties or other revenue tools are a far more desirable way to recognise institutional interests. Standardised rules will reduce legal time and costs. Changing the focus of return will attract investors and support and encourage potential founders. Some CRIs do not give their staff any upside in their discoveries, whereas in the university sector, internationally standard incentives sometimes but not always apply. CRI staff and university staff should operate to similar or the same entitlements. If the CRIs are merged, then a single TTO could serve them.

Developing the private sector ecosystem

214. Small and Medium Enterprises (SMEs) are the largest component of New Zealand's private sector and can play a vital role in New Zealand's knowledge economy. SMEs are agile and can quickly adapt to changing market demands. They often specialise in niche areas, leading to focused innovation and technological advancements in specific sectors. Their size allows for greater flexibility and experimentation, often resulting in disruptive technologies and novel solutions. SMEs have a part to play in job creation and economic growth by driving productivity, creating new markets, and stimulating the overall economy. SMEs typically may have limited resources for extensive R&D and access to resources and infrastructure, and rely on collaboration with research institutions, universities or larger companies to leverage expertise and resources for innovation. Overhead rates can be very inhibitory. However, SMEs also face challenges such as access to funding, and navigating complex regulatory environments. While there has been Government support through a range of initiatives, more does need to be done to support SMEs and their growth in New Zealand to foster their positive contribution to economic growth.

215. The Māori economy is growing fast and has distinctive features, but there are several identified hurdles and barriers. There are many green shoots and innovative enterprises appearing. The dynamics of the Māori economy are somewhat different to the rest of the New Zealand economy, but the sector is demonstrating innovation which will be best supported by building capacity and capability. As more Māori enter university and the research workforce and the demography of New Zealand changes, the importance of this sector to the overall economic and social performance of New Zealand will be critical.

216. The proposed development of ENZ and INZ is designed to directly assist research and innovation companies from the pre-seed stage through start-up to scale-up and for some to then

go global directly or indirectly. The impact on productivity if we develop this sector to scale is demonstrated by international comparison to other small, advanced economies.

217. Large companies typically have more substantial resources to invest in dedicated R&D, which allows them to undertake long-term research projects with potentially high-risk, high-reward outcomes. Large companies have the infrastructure and scale to commercialise and distribute innovative products and services on a national or even global level. They tend to set industry standards and trends, driving innovation across sectors which can create a ripple effect, influencing smaller companies and the broader business landscape. They also attract and nurture top talent in science and engineering. Their training programs and career opportunities contribute to the development of a skilled workforce for the entire country. They often engage in international collaborations, bringing in new technologies and global access and knowledge, thus enriching the national SI&T ecosystem.

218. Attracting more Multinational Companies (MNC) to undertake research and have a presence in New Zealand is one critical path towards improving economic outcomes and fostering the commercialisation of ideas from our science system. Presently, New Zealand has only a small number of relatively small domestic MNCs[25] and there are very limited examples of overseas MNCs establishing a meaningful domestic research presence. The example of Apple is most notable. An innovation in induction technology made by University of Auckland academic engineers led to a spinout company incubated in New Zealand and later bought by Apple, who now have a large research presence in Auckland and whose future is only limited by workforce availability (both domestic and international, due to immigration and housing purchase restriction). Rocket Lab is an example of a New Zealand-originated company that has gone global and is largely owned from offshore but keeps its research basis in New Zealand and is the nidus of a rapidly growing space innovation ecosystem.

219. The value proposition of MNC's in a research and innovation ecosystem is clear. They are the largest investors in R&D – now representing 70% of the global spend, and a significant amount of that is in basic research, especially in the advanced technologies. Internationally, they link closely to PROs and universities. Importantly, they are often the route to the development and scale-up of small companies that may even be bought out by the large company. Rocket Lab's success demonstrates how its mass and focus has created an ecosystem of small companies. MNC executives think globally, and many when in countries take the opportunity to leave the MNC and become the core leaders and executives of start-up and scale-up companies wanting to go global.

220. 'Going global' from the outset is hard, but that is the essence of a successful start-up sector given the small size of our domestic market. While ENZ and INZ are designed to help, the key to successful start-up is executive leadership who understand how and have experience in going global. This is an area where New Zealand is wanting for talent.

221. Attracting MNCs is challenging and globally competitive. For the MNC, the investment must make commercial sense. Many countries take an active and coordinated approach to attracting MNCs, which includes regulatory and fiscal incentives. They coordinate actions across government agents. New Zealand to date has not seriously considered the critical value of MNC research or how best to attract these activities. New Zealand has failed to articulate the value proposition of MNCs across the political spectrum and there are several inherent challenges that need to be overcome. The practical barriers to MNC attraction include our xenophobic attitude,

25 While some MNC representation exists in New Zealand such as the banking sector, professional services firms or several technology companies, we have no headquarters and very few regional headquarters. New Zealand does have several domestic companies that have overseas presence (e.g. Air New Zealand, Zespri, Fonterra).

immigration settings, FIF taxation regime and land ownership rules. Against that we have the attraction of our reputation as a stable, cohesive, multicultural society with higher environmental values and a strong commercial legal system.

222. The reasons an MNC might come to a country are to attract market share (not relevant for New Zealand), for economic advantage in manufacturing or resource exploitation that in turn requires local research and innovation (as has been the case in Singapore and Ireland), to take advantage of workforce (again not immediately relevant to New Zealand), or because of access to ideas and people and in particular key opinion leaders who wish to stay in country (Israel and Singapore have both used this approach). Indeed, the latter is the primary reason why Apple has substantive activity here.

223. There are also opportunities to attract research early in its development that is looking for a relatively small, contained market/system in which to trial things, and where New Zealand might be able to offer benefits or natural advantages that other countries are unable to. The nature of our peoples and geography may be an advantage, but only if we are more welcoming. Here INZ could have a particular role.

International science and innovation diplomacy

224. New Zealand is a small country, geographically remote and ambitious to sustain its future as a high-income developed country. It is a microscopic component of the global research endeavour both in terms of investment levels and the size of the research workforce. The country needs to be much more strategic in ensuring relationships with researchers and research elsewhere for knowledge production, knowledge absorption, and diplomatic and strategic purposes.

225. International science cooperation is core to leveraging New Zealand's small science footprint. In general, our investment in international science cooperation is not strategic but is *ad hoc* based either on the capacity of individuals to build relationships and where possible seek international funding (the possibilities of which were expanded by New Zealand becoming a tier 2 associate member of Horizon Europe), or from the legacy outcomes of various MOUs signed on the side of diplomatic visits. The small amount invested via the Catalyst Fund of MBIE cannot meet strategic needs, nor is it allocated on a strategic basis.

226. As rapidly emerging deep technologies become more central to economic development and thus to security and stability, strategic partnerships become more essential. These need to fit with New Zealand's strategic and diplomatic interests and must be based on our ability to be a genuine partner as well as fitting our overall priorities for national development.

227. The opportunities for growing our innovation sector depend on the ability to go global. As in the trade sector, the Government has important roles to play not only through INZ as suggested, but also through innovation diplomacy.

228. The concept of science and innovation diplomacy is very poorly developed in New Zealand compared to other developed and innovative countries, irrespective of their population size. Countries like Denmark, Switzerland, Ireland, Singapore, Israel, Taiwan, South Korea, etc. all invest in science and innovation diplomacy, albeit in different ways.

229. Science diplomacy allows a country to project its relevance and values globally in ways not always easily achieved by other means. It is increasingly central to trade discussions. Much of the global agenda is concerned with the issues of the global commons such as climate change. New Zealand has both something to offer and in return to gain from more diverse global relationships. The SAE initiative is but one example, and members of that network have been

most helpful to the SSAG in preparing this review. The centrality of Antarctic and Pacific research to global environmental interests also has strong diplomatic and geostrategic dimensions.

230. But critically, nations and large companies now evaluate other nations by virtue not only of size, military capacity or ideology, but increasingly through the lens of the capacity to generate knowledge and then to apply it through innovation. We need to rapidly develop better capacities to export innovation, and conversely to attract partnerships in innovation, including MNCs, a skilled workforce and particular investment.

231. Thus, science and innovation diplomacy are increasingly important for our future. Currently we have three MBIE science officials located offshore (Brussels, Washington and Beijing) and no science and innovation diplomats. Officials based offshore have limited penetration without accompanying senior respected scientists with a diplomatic focus. It is limiting that we have no science/innovation official based in Singapore, Canberra, Silicon Valley, Paris (including the OECD) or London. These are where opportunities of value to our future most likely lie. But cost of offshore appointments is a real factor, and roving science envoys may be a lower-cost solution to our isolation at a time when the dangers of exclusion are real. Senior diplomatic visits often have an accompanying trade mission; increasingly, as in other countries, the role of science/innovation leaders in such missions is becoming more important.

Priority setting

232. The small New Zealand SI&T system cannot do everything. It must make choices and that determines the outcome of higher levels of prioritisation. These choices in turn are informed by the distinct purposes of research: stewardship, policy forming, knowledge generation and exploitation. Each of these classes has different implications for prioritisation, approach, funding and delivery.

233. Much depends on New Zealand's overall economic, environmental and social priorities and strategies. There should be alignment between these broader goals and the priorities within the science and innovation system. This issue will be explored in more depth over the next phase of the SSAG's work, but some preliminary comments are made here.

234. Given the current fiscal situation and our relative size, a whole-of-government approach is needed. However, in the case of the SI&T system, expert input is necessary. PMSTIAC and the Ministry have core roles. Other ministries also must have input into prioritisation of stewardship research and research for public policy development and there needs to be coordination between their own expenditure and that expected through the Ministry.

235. Once prioritisation is set at that high level, other layers of prioritisation need to be developed and implemented by the funding bodies. These encompass multiple dimensions which need to be balanced: workforce development or project-specific considerations; mission-led, roadmap-led or investigator-led initiatives; and the selection of appropriate funding instruments. These generic questions must be considered alongside the domains of interest and then be prioritised by national need and contextual factors amongst the four primary research classes. Our second report will consider funding processes and appropriate allocation mechanisms.

236. Industry and civil society both need structural conduits into prioritisation processes.

237. Currently in contestable research funding, beyond some limited strategic priority setting, decisions are generally based on criteria of excellence and relevance/potential impact; both are relatively subjective terms. Excellence can only be examined prospectively in terms of the questions being addressed, the methodologies proposed, and the team employed. Peer review

remains the best judge of this criterion, but peer review itself is complex and new approaches may need to be considered. But the test of excellence remains key – as Dame Bridget Ogilvie, former director of the Wellcome Trust once said in a speech in Auckland, "second rate research is a waste of money". New Zealand has had difficulties in ensuring peer review, perhaps because of the small size of our system and our rather low global presence. Conflicts of interest, recognised or not, are difficult to manage in a small ecosystem.

238. Evaluating and assessing relevance or impact of the research can be even more complex, as it can be viewed from various perspectives and over different time frames. An alternative framing to claiming impact could be to justify why the research should be done in New Zealand and funded by the Crown, given our size and location. An international panel evaluating health research for MBIE, and the Ministry of Health suggested a range justification for why a piece of research should be undertaken in New Zealand and funded by the New Zealand taxpayer.[26] These encompassed all stages of research from the most fundamental to the most applied. Such an approach creates a logic: that research funding should consider excellence, strategic priorities and the justification for why this should be undertaken in New Zealand and funded by the Crown. These issues of assessment criteria will be a matter for consultation in the next stage of the review.

239. It is critical that a portion of the research budget is allocated for basic research and knowledge development in every domain. The history of research application shows that many innovations arise unexpectedly from research that never set out to focus on an application, and even if it did, the final application may be in a very different space.

240. Prioritisation in the innovation space is based on expert assessment of TRL, market potential, IP where appropriate, and the quality of the business plan and team. These are expert decisions to be made by entrepreneurial professionals in the private sector. ENZ has a supportive role.

Workforce

241. A major focus of the next report and that of the UAG work underway will be on our academic, research, science and innovation workforces. Their training, their career pathways, their retention in New Zealand, in both the public and increasingly in the private sector, are key to New Zealand's future. A worrying dimension is the unsatisfactory state of STEM education in the school years. There is also a critical need to continue to build a more diverse workforce. This initial report will merely make a few preliminary observations.

242. The nature of our workforce does not reflect either the current or future more diverse demography of New Zealand or the reality that many science/technology graduates have their future in the private sector. The future workforce must build its Māori and Pacific Peoples workforces by investing in capacity and capability.

243. Entrepreneurship training in universities is only patchy and usually delivered only at an advanced level. Increasingly around the world, this is moving into undergraduate education, both in the natural and social sciences. As traditional knowledge boundaries are blurring, especially between natural and social sciences, and with the emergence of transdisciplinarity, the current training models are not well positioned.

244. PhD training in New Zealand still assumes that the graduate is most likely to have an academic career. There is a need to look at alternate structures that will produce graduates who will

26 External Advisory Committee on Health Research. (2019). *Report of the External Advisory Committee on Health Research to the Ministries of Health and Business, Innovation and Employment*.

enter the private sector or have other roles in the public sector. The industrial PhD is one such approach which should be further developed.

245. Early career researchers face highly precarious employment arrangements, especially in universities. Too many researchers remain on short-term contracts indefinitely within universities. Universities have been slow to recognise promotion activities other than classical research. The PBRF has in that regard not been helpful. The future of incentive-related funding is to be jointly discussed with UAG.

246. New Zealand needs to attract key opinion leader scientists. To do that it must create a framework where a sustained critical mass of activity is possible, and attraction should be targeted to where the value to New Zealand of the domain of interest is unequivocal.

247. Researchers in PRONZ and potentially in universities should be able to take partial or full leave of absence to follow their invention into the private sector before making a decision as to their long-term future.

Leadership

248. A constant theme throughout this report is the need for expert leadership. Too many decisions have been made in the science and innovation system by non-experts. The nature of the needed expertise depends on context. Those serving on councils or advisory boards must be chosen for expertise. Research and innovation require sophisticated leadership from those who understand the culture, the technologies and the ecosystem.

Next steps and transitional considerations

249. Structural change is not to be undertaken lightly, but the SSAG is clear that New Zealand cannot rapidly address economic, productivity, social and environmental challenges without strategically informed change. The change in PRO structure must be carefully managed – it should start with governance and establishing strategy, followed by rationalisation of back office and TTO functions, and over years the arrangements within the merged CRI structure can evolve as duplication and gaps are addressed and a more obvious hub-and-spoke model with the university sector evolves.

250. After several decades of the current model with relatively minor adjustments, change is urgent but will take time. It must be sustained over political cycles, and that will need to be accompanied by the recognition that there has been significant underinvestment in the sector. Certainly, there are inefficiencies and barriers that restructuring aims to address, but the success of restructuring will depend on attention to detail in planning each step.

251. What we recommend cannot be done in a single step. Much will require careful and expert change management. Steps that can be achieved rapidly without disruption are the establishment of the PMSTIAC, redesign of the PMCSA role, and removing many of the barriers between CRIs, universities and the private sector. A transition planning group should be appointed with expert membership to commence establishment of the PRONZ. The group should focus on the strategic goals, the shape of the entity, transitioning aspects from exiting CRIs, and its long-term adaptive scientific structure built around needed capabilities to meet New Zealand's needs, rather than first looking for efficiencies in duplicated systems. Work to establish INZ and ENZ should be given priority. Work on the shape of the funding mechanisms should await our further consultation and advice in our next report.

252. It is important for the broad range of New Zealanders to feel that they are benefiting from the innovation journey. Some countries enable this do so by investing small amounts of sovereign funds in the local innovation economy. Already the Elevate Fund administered by New Zealand Growth Capital Partners (NZGCP) has done so on behalf of the NZ Super Fund, and it has been commended by the venture capital sector as an important element. Such approaches should be encouraged across the NZ Super Fund, KiwiSaver funds, ACC, etc. Well-managed as they may be, as has been the case by NZGCP, the Crown might offer comfort to those funds by underwriting against such public investments. Even a 0.5% investment by such funds would change the innovation landscape significantly.

253. Science and innovation are fundamentally human endeavours, and the investment in our workforce is extensive, but change is needed. Researchers must be supported to be productive in the transition proposed. The institutional changes suggested are essential, but institutions *per se* are not the focus of the changes recommended, rather they are simply frames under which science and innovators can operate for New Zealand's benefit.

254. The work to date of the SSAG has been focused on the role of research and innovation in New Zealand's future, the state of the system, and the overall architecture necessary for a more efficient and effective system. There is much yet to evaluate and explore with regards the various components of the system; infrastructure and workforce issues; the use of research by Government itself; issues of access to data generated from taxpayer funds; funding allocation mechanisms; the types of research activity; research assessment; the interface between universities, PROs and the private sector; the role of private research providers; and practical aspects of an effective outward-looking innovation system. Further consultation will lead to these, and other aspects being addressed in the second report. The SSAG continues to coordinate its work with the UAG.

Final remarks

255. New Zealand has many outstanding scientists in both the public and private sectors, with some green shoots appearing in our innovation system and a few taller trees emerging. We need an integrated and strategically overseen system that allows researchers, scientists and innovators to contribute more effectively to our economic, social and environmental health. This is a once-in-a-generation opportunity to make a step change that will have enormously positive consequences for New Zealand.

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