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A Resilient Research, Science & Innovation Sector Enabling Post-Pandemic Economic Transformation

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Not Government Policy: Rather than being a formal synthesis of evidence, this document outlines the professional opinions and advice of independent Science Advisors

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Executive Summary

This document sets out how our Research, Science and Innovation (RSI) sector might remain resilient to the "once in a generation" societal changes that will result from the pandemic. Resilience of the RSI sector will allow it to provide crucial help in the recovery from the economic, societal and environmental consequences, while building on the critical role the RSI system has made to the immediate response. We consider various current and possible future impacts from those changes, in the context of the worldwide impact on the overseas RSI sector. Nevertheless, due to the rapidly changing nature of the pandemic, we acknowledge that some aspects of this document will doubtless become out of date. We discuss how New Zealand's RSI sector might lead our economy's recovery in the medium- and longer-term, as a continuation of the way it has informed and dictated our responses to date.

We make four critical points:

1. COVID-19 has showcased the importance of the RSI sector, providing critical understanding of the required health response through to research-based evidence.

2. The RSI sector will play a fundamental role in supporting our economic recovery and future transformation.

3. The RSI sector's resilience and future is now more vulnerable: institutions are at risk due to fewer students; skills shortages are likely; connectivity and funding access all more uncertain.

4. MBIE needs to take some bold steps in the near term to ensure that the RSI sector can make the most of the opportunities presented and meet the challenges head on (e.g., changes to funding systems, immigration, investment in digital infrastructure).

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Context

COVID-19 disease was declared pandemic by the World Health Organisation on 11 March 2020[1]. Aotearoa New Zealand's response has involved closing of borders and a stay-at-home "lockdown" (formally, Alert Level 4) that was described as being one of the strictest worldwide.[2] Subsequently, New Zealand progressed on 28 April 2020 to Level 3 (Restrict), moved to Level 2 (Reduce) on 14 May 2020 and then to Level 1 on 9 June, based on scientific advice from Public Health experts. New Zealand is now one of the few countries in the world to eliminate the virus and effectively resume normal business and community activities.

By 1 July 2020, the number of cases reported worldwide was estimated at >10 million with >510 thousand deaths[3]. Even if this case figure is an order-of-magnitude underestimate (i.e., the true figure is 100 million cases), it is dwarfed by the world's population of 7.8 billion, a factor of ~78 times larger. There is thus a huge pool of virally susceptible people. In the absence of a vaccine or an effective therapeutic, this number is easily enough to keep the pandemic going for many months (and even years) before herd immunity is acquired, which itself depends on the degree and duration of any immunity amongst people who recover from COVID-19, something that is currently unknown. If control effects are relaxed (as is currently occurring in many western countries), it would seem that the number of infections will likely increase dramatically. Whatever the case, the virus will almost certainly not be contained overseas until a vaccine is developed and implemented, probably not for 18-24 months or longer. We note that this period of time for vaccine development needs to be seen in the context that we've never developed a successful coronavirus vaccine before[4]. An alternative view, expressed in a recent *New York Times* article, suggests that we may have to learn to live with COVID-19 as we have with HIV-1, recalling that until the advent of HAART drugs for AIDS, HIV-1 mortality was 76%, whereas after the HAART regime was introduced the mortality rate dropped to 12%. [5]

Cognizance of this likely situation needs to underpin the New Zealand RSI sector (and other) planning especially as, though the history of COVID-19 is too brief to be definitive, it is prudent to consider as one of the scenarios that SARS-COV-2 will become endemic. This assumption is based on four other human COV (hCOV) viruses that are endemic the world over [6,7] and has consequences for what post-Alert Level 1 planning might entail, including any plans concerning the mitigating of resurgent disease. While New Zealand has effectively eliminated the disease, there is likely to be on-going risk of re-infection and future outbreaks as a consequence of failure to adequately isolate those entering our borders[8]. Medium-term border restrictions will also have an on-going impact on the RSI sector.

[1] https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

[2] https://covid19.govt.nz/alert-system/covid-19-alert-system/

[3] https://coronavirus.jhu.edu/map.html

[4] https://www.abc.net.au/news/health/2020-04-17/coronavirus-vaccine-ian-frazer/12146616

[5] https://www.nytimes.com/video/world/100000007137382/world-health-organization-coronavirus.html

[6] V.M. Corman, D. Muth, D. Niemeyer and C. Drosten. 2018. Hosts and sources of endemic human coronaviruses. *Advances in Virus Research* 100: 163-188. doi: 10.1016/bs.aivir.2018.01.001.

[7] A.J. Brown, J.J. Won, R.L. Graham RL, K.H. Dinnon, A.C. Sims, J.Y. Feng, T. Cihlar, M.R. Denison, R.S. Baric and T.P. Sheahan. 2019. Broad spectrum antiviral remdesivir inhibits human endemic and zoonotic delta coronaviruses with a highly divergent RNA dependent RNA polymerase. *Antiviral Research* 169: 104541. doi: 10.1016/j.antiviral.2019.104541.

[8] https://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=12340776&ref=art_readmore

Implications for the RSI Sector

1. Impact on RSI Worldwide will be Severe and Greatly Affect New Zealand

Apart from having immediate, society-wide economic, social and environmental consequences, the pandemic will severely impact the world's various RSI sectors[9]. Even places that appear at this stage to have avoided some of the worst immediate effects of COVID-19, such as Australia, are anticipating major upheaval in their research systems[10]. From New Zealand's viewpoint, these changes in the global research-sector labour market have both positives and negatives: it may be easier to attract talent to New Zealand (assuming there is some immigration), but the global job prospects for current research students and early-career researchers could be poor. Existing international collaborations and funding arrangements may also disappear. And, of course, much depends on whether or not similar upheavals will occur in New Zealand. Any impacts here will disproportionately affect under-represented and vulnerable groups (notably, Māori, women, early-career researchers, those on fixed-term contracts)[11,12], thereby harming the diversity, capacity and capability of our upcoming generation of researchers

2. International Mobility will Remain Restricted for Months (if not Years)

The collapse of international air travel has already changed the way research is carried out. Over the past thirty years, New Zealand researchers have become used to travel overseas to international conferences and workshops. Such travel has greatly facilitated collaborative research and enhanced global connectivity. In the future, collaboration is going to look very different, even if travel between New Zealand and Australia becomes possible. Equally important, the New Zealand research workforce has a very large overseas component[13]. Travel and immigration restrictions may mean that fewer PhD students and other researchers will come to New Zealand, even if New Zealand is seen as an attractive and safe destination. This reduction in foreign researchers coming to New Zealand has and will have an impact on the capability of our RSI workforce. A co-ordinated nationwide response to these issues, possibly facilitating immigration of selected groups (e.g., PhD students and postdocs), is likely to be more effective. In addition to the positive research and development input into New Zealand's successful response to COVID-19, could attract further overseas researchers. If mobility is restricted for years, there will be a genuine need for more explicit workforce planning across the whole RSI sector.

[9] A recent editorial in *Nature* argues that universities worldwide will need significant financial assistance in order to be able to carry out the research required to drive post-COIVID recovery. See https://www.nature.com/articles/d41586-020-01788-6

[10] Australia's Chief Scientist, Dr Alan Finkel, for example, predicts that ~7,000 FTEs of research-related academic staff could be lost from Australian universities, a figure that is an alarming 29% of the 24,075 academic staff research FTEs. Some 9,000 international research students will not resume their research in Australia in 2020, in part because of travel restrictions. See https://www.science.org.au/sites/default/files/rrif-covid19-research-workforce.pdf

[11] For the disproportionate effect on women in STEM professions in Australia see https://www.science.org.au/sites/default/files/rrif-covid19-women-stem-workforce.pdf

[12] Indeed, some fixed-term science staff have already lost their jobs. https://www.rnz.co.nz/news/national/417688/massey-university-science-faculty-cuts-casual-staff

[13] For example, more than 45% of PhD students are from overseas. Z. Park. 2017. *Moving places: Destinations and earnings of international graduates*. Ministry of Education. Available at https://www.educationcounts.govt.nz/publications/80898/moving-places-destinations-and-earnings-of-international-graduates

3. Importance of a Diverse and Robust RSI Sector

The pandemic has highlighted the critical importance of a diverse and robust RSI sector, with the capability and capacity, supported by appropriate infrastructure, to respond nimbly to unforeseen events. Obviously, in the short term, health researchers (e.g., epidemiologists, virologists, clinicians) have been at the forefront of COVID-19 research efforts that have positioned us well for recovery[14], but the longer-term response will draw upon a far broader suite of disciplines (e.g., economics). In our planning efforts, it will be essential to ensure that diversity right across the full spectrum of the research sector is maintained[15]. Support for mātauranga Māori will be critical for building system resilience and distinctiveness. Social and economic research is also going to be crucial to address the social costs of COVID, especially for disadvantaged communities, and will require strong ethnic and indigenous elements to be researched. The lessons learned from the pandemic (and, indeed, other recent crises) can inform the RSI capability, capacity and infrastructure needed to respond to different types of future crises (e.g., natural disasters, biosecurity incursions etc.)

4. Continued Investment in RSI

The critical importance of the RSI sector in New Zealand's response and recovery to date shows that maintaining the strength and diversity of the RSI sector is paramount. Moreover, the sector will continue to be fundamental in our capacity to pivot as a nation, and support industry and hence the economy, during the recovery. Although there is clearly a need to redirect some research funding and other support in the short term, in the longer term we must ensure investment in RSI is supported across the board. We need to be careful not to "overdo the pragmatism" and reduce or cut RSI from government and industry balance sheets altogether – more often than not R&D is the first thing to "go to the wall" when economizing. These concerns have implications for the RSI funding system, especially the ability to support longer-term research programmes and capability. What might suit MBIE's practicalities might not be best for an-RSI led recovery from COVID-19 in the medium to long term.

5. Co-ordinated Action

Drawing on the diversity of the RSI sector has a second benefit in that it can generate a wider range of potential solutions to problems, avoiding the narrowness of a top-down, centrally-driven agenda. Nevertheless, there is a price to this diversity, namely a robust yet nimble process for selecting which ideas to support and we should learn from the Canterbury and Kaikoura earthquakes[16]. The system should allow for flexible and "fast-fail" outcomes. There also needs to be some degree of co-ordination to ensure a broader framework that enables co-operation and synergies between different research efforts, agencies and ministries, especially if we are to shorten the pathway from research to its use by decision makers. Again, this requirement has implications for MBIE's functional role in RSI policy and investment and how it works across the wider government sector.

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[14] Nevertheless, the list of research areas currently involved is far broader: ethicists, computer scientists, mathematicians, psychologists, social scientists, chemists and veterinary scientists, for instance.

[15] Doing so is critical in the response to COVID-19, but also in ensuring we are ready for the next crisis, for example, a major earthquake or volcanic eruption. Indeed, we have already seen, earthquakes do not delay themselves because of a global pandemic.

[16] R.J. Woods, S.K. McBride, L.M. Wotherspoon, S. Beavan, S.H. Potter, D.M. Johnston, T. M., Wilson, D. Brunsdon, E.S. Grace, H. Brackley, & J.S. Becker. 2017. Science to emergency management response. *Bulletin of the New Zealand Society for Earthquake Engineering* 50: 329-337. doi.org/10.5459/bnzsee.50.2.329-337 For example, "the absence of established, transparent, widely accessible collaboration pathways and structures" among various large research agencies necessitated the rapid development of *ad hoc* arrangements, which would ideally have been supported by a clear decision-making structure.

6. Economic Opportunities

There are significant economic opportunities for New Zealand especially now that we have eliminated the virus and assuming that we can maintain that status. Since such elimination appears unlikely overseas for many months at least, New Zealand would be in a uniquely advantageous position. Under this scenario, many of New Zealand's export sectors could have market advantage. These sectors include the film and digital industries, and those industries associated with food and beverages. Unlike New Zealand, many countries cannot produce sufficient food to feed their people, and it is therefore likely that there will be increased demand for our primary products. The research sector could play an important role in creating and capturing greater value, developing traceability and security systems, and balancing growth and sustainability in primary production. Partnering with Māori will be essential given they are playing and will continue play a key role in innovation within the sector. Diversifying the production base of the food sector and increasing the offerings in healthy, safe food is also expected to play a key role but will likely require multiple government investment tools to encourage private sector investment in the development of the sector. Likewise, it may be opportune to grow our high-value manufacturing and tech sectors at this time. The pandemic has also shown weaknesses in global supply chains: identifying innovations to allow quick substitution by local manufacturers when needed (or indeed new onshore manufacturing of novel products) provides economic opportunity and increases our resilience. Many of the world's talented tech entrepreneurs will be looking for a safe place to live; our home-grown talent will want to stay here; capital markets will be looking for the right and safe places to invest; and our track-record[17] shows we have the right ingredients in place.

7. Accelerating Longer-term Government Priorities

Several commentators have also noted that the crisis provides an opportunity to address various other challenges facing the country[18]. Our social cohesiveness has been fundamental to the success we have had against COVID-19, and will undoubtedly contribute to our economic recovery and response to future challenges. If we have to re-think fundamentally how we carry out many of our business and industry practices, we may be able to solve several problems at once. For instance, research advancing the government's priority to transition to a low-carbon economy could be carried out at the same time as research into how to restructure the tourism sector, which to date has relied on long-distance airline travel. Indeed, the tourism industry, which is one of the hardest hit in New Zealand and will probably not be able to return to full function until the virus is contained overseas, is clearly a priority area for transformational change. Research can also play a key role in re-invigorating the manufacturing sector and advancing the government's infrastructure projects, potentially through a stronger problem-focussed research portfolio. Social science will be essential and especially important for Māori given their interests in tourism and role as kaitiaki of te tai ao. There is also an opportunity for research to help NZ address some of the long-term societal inequities which have been exacerbated by the COVID-19 pandemic[19]. Finally, the COVID-induced rapid transformation to a digital mode of working of many in education means that there is an opportunity for R&D and, indeed, commercialization of novel products in this area.

[17] TIN Report, Technology Investment Network.

[18] For example, the urgent post-COVID need for action in the environmental space has been discussed in depth by A. Bardsley, P. Gluckman and C. Mace, 2020. *The Environment is Now.* Koi Tū: The Centre for Informed Futures, University of Auckland.

[19] Several of those who provided feedback argued that such social-sector research was currently poorly supported. See also comments under point 11.

8. Engagement with Low-intensity R&D Sectors

The example of the tourism industry reveals an additional opportunity, namely the chance for researchers to engage with a sector that has largely remained unaffected by RSI initiatives. Clearly, there is no going back to doing more of the "same-old, same-old" tourism practices, which risked losing its social license to operate pre-COVID-19 (e.g., impacts of freedom campers). More widely, the largely positive view that the news media (and, presumably, the general public) have had of scientists and the research community during the pandemic, provides a general opportunity for greater interaction between business and industry and researchers across a range of sectors. This will also require strengthening within the RSI system to deliver knowledge for impact. Whether or not there are suitable government funding vehicles to facilitate such engagement needs to be considered.

9. Structural Capability in the RSI Sector

The pandemic has highlighted the ability of the RSI sector to come together in times of need, but also that there will be a need for ongoing coordination across the sector. For example, there is no coordinating structure (e.g., National Science Challenge (NSC), Centre of Research Excellence (CoRE)) in the infectious-diseases space. Nor is there a supporting structure with a focus on the issues that underlie many of the socio-economic problems faced by large segments of the New Zealand population. In addition, there are some aspects of New Zealand being an island nation, far from the rest of the world, that mean we need to retain some domestic capability. For instance, in the area of genomics, much medically oriented COVID-19 research relies on genetic-sequencing technology that, because of the pandemic, was accessible only locally. The trend to sending sequencing samples overseas could easily have led to New Zealand's facilities being run down – we need to beware of these apparent false economies. This example reveals the need to maintain and build our RSI infrastructure. All of these matters have significant implications (including budgetary consequences) for MBIE's long-term strategic planning on infrastructure for the RSI sector.

10. Positive Response to COVID-19

Having said this, there is also a good story to tell here about the way in which some infrastructural elements have been able to be re-purposed quickly to help with the COVID-19 response (e.g., PC3 laboratories, RV *Tangaroa* as a potential hospital ship, development of domestic supplies of PPE and reagents for testing). This nimbleness is, in part, a result of the delegation to research organizations to make decisions in the appropriate context, together with the high degree of connectedness among researchers in the country. Some parts of New Zealand's research infrastructure have worked very well. The moral here is that, in future planning, we need to be careful not to throw the baby out with the bathwater. There is value in the ability of larger institutions who have the resources to be flexible with infrastructure or capability.

11. Education & Social Sectors

A wide range of the education sector (and notably Māori and Pasifika) has responded positively to the challenges of on-line learning, providing a significant foundation for the longer-term changes. Nevertheless, some students have faced the consequences of being on the wrong side of the digital divide, inequalities that are compounded by other economic and societal aspects of their situations. Research that builds on what schools, families and whānau and students have contributed, including the cultural expressions of whānau and Pasifika households, will be important. More broadly, the threats to our physical and economic health and other dimensions of our social and cultural wellbeing should not be ignored. Not the least because the strength of our educational and social sectors underpins our recovery, there is a strong case

for increased RSI in, for example, improved educational practices, social cohesiveness and the health of our cultural institutions. Such investment, of course, provides a natural vehicle for genuine research partnership with Māori.

12. Suitability of MBIE Funding Mechanisms

Some sorts of research that would contribute to the recovery from the pandemic are not those that would likely be funded through the Ministry of Business, Innovation & Employment's (MBIE) current mechanisms. Perhaps most notably, research that uses known techniques and approaches, but applies them to slightly different cases, with a focus on solving a problem particular to that case, might not easily meet the excellence criteria of several funds. In particular, the collection of data (especially long-term datasets) that then helps build and inform observation and hypothesis, adapting overseas technology or approaches, or applying existing knowledge and incremental advances. This kind of research might have been funded from the cross-departmental fund proposed in a recent (unsuccessful) MBIE budget bid. The need for instruments to support the application and uptake of research also applies to local government, Māori and industry. Many of these points might aply to government funding more widely.

13. RSI & Evidence-informed Policy

More widely, existing (and novel) RSI results should be fed into government decisions concerning the recovery; evidence is critical to good and enduring government policy. For instance, American research has shown that money spent in response to the Global Financial Crisis on public-transport projects produced twice as many jobs per dollar as did roading projects[20]. The Departmental Science Advisors across government can help in ensuring various decisions are research evidence based and that any science input is weighed accordingly in policy decision making. MBIE and Treasury may also have a role here.

14. RSI future workforce

As already noted, New Zealand is currently dependent on overseas recruitment of science researchers within a number of areas of core capability. At the same time, there is likely to be a demand for significant levels of retraining of people who have lost their jobs as a result of COVID-19 related business failures (e.g., aviation sector). Changes may need to be made in incentives or new initiatives across the science system for supporting the tertiary education system[21] if it is to increase the numbers of New Zealand graduates in areas of national need and reduce our reliance on employing researchers from overseas. Growing our own research capability will be essential if New Zealand is to build a more resilient RSI sector.

15. Citizen science and data governance

The implementation of COVID-19 control measures has highlighted the importance of data for science, decision making and management of the pandemic. Digital connectivity and data have not been fit for purpose, and new systems for contact tracking and data collection are still to be implemented or developed. There is a need to collect data on the impacts of COVID-19 on our businesses and communities if New Zealand is to undertake the research required to inform and build national resilience to future hazardous events. Opportunities for collection of this

[20] Center for Neighborhood Technology, Smart Growth America, U.S. PIRG. 2010. *What We Learned from the Stimulus*. Available at https://smartgrowthamerica.org/resources/what-we-learned-from-the-stimulus/

[21] We note that financial considerations were leading to retrenchment of some elements of tertiary-sector science even before the COVID-19 pandemic. In addition, some feedback considered that the current state of university finances might preclude them capitalizing on the opportunities to attract talent to New Zealand.

data need to be considered as an essential service in future lock-down scenarios. The regulatory environment associated with data ownership, sovereignty by Māori, privacy and governance within New Zealand needs to be reviewed to ensure it is fit for purpose. This review will be important for managing both existing and future challenges to our well-being.

RSI Sector Opportunities: Considerations and Reponses

The current pandemic has had massive economic and social impacts, both globally and nationally. While some of these impacts will be reversible in the medium term, many of these can be expected to result in enduring and long-term change. Such changes will present both challenges and opportunities, and the RSI sector will need to consider how to respond to these changes. Issues specific to the RSI sector over the medium to short term, considerations associated with its future structure and function, and its response to meeting the nation's needs, not only the short to medium term, but the next decade, are outlined below.

New Zealand's debt level will have increased significantly by the end of the pandemic, and economic recovery in the medium term (1-3 years) will be a key Government driver.

The RSI sector will need to play its part in helping to accelerate socially equitable economic recovery, in part by identifying and capitalizing on new opportunities. It will also be important for the system to focus on areas likely to provide new economic opportunity in the immediate future. This change of focus may require modification of some current science investments over the short term (e.g., changes to fund investment signals) in order to explore opportunities to accelerate the application and uptake of existing knowledge by the public and private sectors Nevertheless, any modifications need to be made very carefully, to avoid long-term damage to the resilience of the RSI sector. This resilience requires investment supporting the full range of basic to applied research; hence, in spite of governmental fiscal constraint, targeted spending would ideally be additional spending[22]. Some changes are essential to boost access to science expertise, advice and extension, especially for SMEs that are often resource limited and likely to be struggling financially due to COVID-19. Funding instruments that significantly increase public-private co-investment may also need to be developed (noting that SME resources and the risk appetite of the private sector will have been significantly reduced, and hence the impact of R&D tax credits will likely be lessened). Such instruments are more likely to create impact in the medium term but will also require genuine support from businesses. Mechanisms that support and encourage SMEs to work with researchers may need to be enhanced.

Māori and Pasifika communities will inevitably be strongly affected by COVID-19.

Similarly, Māori enterprises will likely be disproportionately impacted due to their predominance in the primary production and tourism sectors. The RSI sector has a key role in working in partnership with Māori to help revitalize and continue growth of the Māori economy post-COVID. These effects will need to be factored into future MBIE priorities and investment processes[23].

Universities, CRIs and IROs all face major financial challenges arising from the COVID-19 pandemic.

[22] There was deep concern among those providing feedback about what sorts of modifications should be made. Most especially, reprioritizing existing funds was seen by some as cannibalizing research funding, and it could unintentionally and disproportionately affect early-career researchers. Others argued that cancelling funding rounds risked long-term damage to the research sector and flow-through effects on the NZ economy. In spite of the concerns about government debt levels, feedback consistently argued for targeted spending to be additional spending. There was universal support for the maintenance of broad RS&I investment encompassing the full range of basic to applied research.

[23] https://theconversation.com/recession-hits-maori-and-pasifika-harder-they-must-be-part-of-planning-new-zealands-covid-19-recovery-137763

The collapse of the educational market for international students, for example, is hitting the universities hard[24]. A number of MBIEs investments are also dependent on international postgraduate students (e.g., NSCs). CRIs and IROs will see a significant reduction in fee-for-science services that they are now heavily dependent on to support essential national capabilities. Institutional decisions about how to respond to these significant revenue declines is likely to impact national research capabilities. Minimizing the detrimental consequences from such decisions will require a whole-of-government response, and thought needs to be given to how to make our RSI institutions more robust and resilient to any future disruptive events.

The COVID-19 pandemic has shown the world that knowledge sharing has been key to the rapid development of solutions to respond to challenges faced in every country.
Post pandemic, our RSI sector must be able to keep fostering international collaborations not only to leverage expertise for research and technology development but also to open doors to economic growth through partnerships and investment opportunities. There is room to change the current frameworks for international collaborations and open doors to joint funding pools for targeted initiatives supported by, for example, science-cooperation treaties.

Immigration restrictions will hamper research in some areas where New Zealand does not currently have or produce sufficient talent[25].
Many research subjects are currently dominated by overseas scientists, postdocs and postgraduate students. Although a "jobs for kiwis" approach might be politically popular, the cultural and disciplinary diversity resulting from international talent coming to New Zealand is at present essential. Recently recruited overseas scientists are currently unable to travel to NZ to take up their positions. MBIE has a part to play here in its role in regulating immigration. There is also opportunity to explore how New Zealand could better grow its own research talent through new approaches or improved integration between education and the government's RSI system. Any new initiatives will need to link with the need for succession and diversification within our science workforce.

Nationally important science infrastructure will need to be maintained and, in some cases, expanded; such maintenance is critical for the resilience of the RSI sector as a whole.
The pandemic has highlighted the risks associated with shedding national infrastructure and becoming dependent on international capability. Much of our nationally significant infrastructure is not fully funded (e.g., databases and collections, RV *Tangaroa*), and dependent on finding additional funds from other sources (e.g., philanthropists, private sector, international research organisations). Securing these funds in the short to medium term is unlikely.

Any changes to MBIE's investment systems need to incorporate the opportunity to accelerate existing government priorities, such as transitioning to a low-carbon economy, building social equity and long-term resilience, embracing diversity, meeting Treaty obligations, and reversing environmental degradation.

[24] Nevertheless, if NZ becomes one of the few countries to eliminate the virus, long-term international students may choose to come here and be happy to be temporarily quarantined.

[25] One example is Peter Hunter's ABI group at the University of Auckland, which generates significant numbers of spin-off companies and hence employment. This group has relied on importing a substantial number of overseas biomedical engineering students to complement its kiwi graduate student intake. CRIs are also dependent on overseas scientists to support national capability needs (e.g., fisheries modellers, high-performance computing support and management, atmospheric physics/chemistry, space science, data science, …)

New Zealand's ability to control and potentially eliminate COVID-19 provides an opportunity to attract RSI capability that we need or lack.
In some areas, perhaps most notably in the area of Antarctic or agricultural greenhouse-gas mitigation research. New Zealand could provide the key hands-on research work for international research programmes. This prospect should be considered when implementing any changes to the science system.

The pandemic has highlighted the shortcomings of public-sector IT and data systems; even MBIE's IT and data systems have struggled.
With the reduction in air travel expected to last for many years to come, fit-for-purpose IT will be essential for maintaining and building national and international science networks, both for MBIE and research providers. Accelerating New Zealand's digital transition will be key across the entire RSI sector in the short to medium term. Co-design of these systems with Māori will be essential and will provide community benefits beyond Te Ao Māori.

Managing New Zealand's response to COVID-19 has been dependent on quality data and data science for understanding, tracking, decision making and managing COVID-19.
While MBIE has invested in and implemented a data-science platform to build national capability, primarily through the universities, this initiative does not address the need for the application of data science across the wider science system. Such application across key business sectors could help accelerate New Zealand's economic recovery and help build resilience across the public sector to events such as pandemics and other hazardous events. This issue should be considered in any future research investment decisions.

Some of MBIE's current investment instruments are expensive to operate and administer, and changes to these instruments could help free up additional research funding and reduce costs for research providers.
Greater trust in research providers and their governance and management, along with greater baseline research support, could help realize these cost savings[26]. Areas that could be reviewed include:

- *Administration*: Research providers estimate that an Endeavour Programme proposal costs on average $500k to prepare[27]. Given that MBIE receives around 160 programme proposals per year for about $25m of funding, this annual preparatory cost is estimated to be more than three times that of the funding available. The National Science Challenges, as currently operated, are seen as having a high cost of administration[28]. Changes to investment processes to reduce administration and operational costs would free up funds for research. The system has seen a proliferation in small instruments, such as Regional Research Institutes, SSIF Platforms and NSCs, that require significant contract administration and tend to support large numbers of researchers. They often also have contestability within them that trends towards a 'co-oper-tition' model, driving researchers to compete rather than collaborate in a coherent way. There is opportunity to review and improve the efficiencies of these instruments.

[26] We acknowledge that these concerns are not necessarily driven by COVID-19. Nevertheless, if the RSI funding landscape is reviewed as part of delivering a better recovery from COVID-19, it would be sensible to use this opportunity to address these matters, potentially freeing up more resources for research.

[27] Estimate from a number of the Crown Research Institutes.

[28] Although there was not universal agreement, several people giving feedback argued that the CoRE model was significantly more efficient at delivering excellent research with impact.

- *Baseline support*: Research providers in New Zealand are overly reliant on contestable sources of funding to support their research, and baseline funding (e.g., Strategic Science Investment Fund, Performance Based Research Fund) levels are low compared to the quantity of research actually carried out. High levels of contestability across the science system increases operational costs, puts national capability at risk, hinders collaboration, disadvantages young researchers and creates financial uncertainty for institutions. University researchers depend on Marsden, Health Research Council, Endeavour and other contestable funds (e.g., NSCs, CoREs) for much of their research, while on average 70-80% of the revenue required to support CRI research activities is secured through competitive processes. While contest plays a key role in identifying and promoting science excellence, any review of the science system over the coming months should consider how to reduce reliance of research providers on contestable processes to reduce risks to and increase resilience of our research institutions. Partnerships within the science sector, and with Māori and the sectors they serve, are likely to be greatly enhanced if these interactions are not subject to funding uncertainty. Such changes would create opportunity for the RSI sector to be agents of change through working more collectively, both within and outside the sector.

Conclusion

More than ever, an opinion piece of this nature provides a snapshot, reflecting a response specific to that time. With this is mind, there are policy and operational settings encompassing the RSI sector that New Zealand might envisage changing or enhancing in order to maximize the impact of RSI on our economic recovery and revitalization.

The central message of this document is that a robust, resilient and adaptive RSI sector has a clear and critical role to play in driving the transformational change needed in the economy and New Zealand as a whole, as we pivot from the COVID-19 pandemic. We are optimistic that New Zealand's RSI sector can greatly enhance this recovery, but we must act now if we are to achieve the greatest effect. The pandemic has shown that our RSI research institutions, while responsive to the need to support the government's management of the virus, lack resilience. There is now an opportunity to review the government's RSI investment systems and institutions to ensure their research, and the data that underpins it, meet the nation's future needs.

The key COVID-19 impacts on the RSI sector, along with potential areas of change to improve the ability of the RSI system to meet our nation's future needs, identified in this discussion document are as follows:

- Research collaboration and reprioritisation across the RSI sector has provided guidance that has been fundamental to the government response and management of the COVID-19 pandemic.
- The effects of COVID-19 on the global RSI sector will have a significant short- to medium-term impact on New Zealand research, especially through the reduction in numbers of international students and early career researchers as well as the reduced ability to connect with overseas researchers and to recruit expertise the nation does not have.
- The pandemic has highlighted the need for a robust, resilient, diverse and nimble RSI sector, and the need for greater capacity in some disciplines, especially public health and social science, and more Māori and Pasifika researchers.
- Major institutions in the RSI sector will have significant financial challenges over the coming years, and on-going multi-agency support of the sector will be critical to maintain national research capability.
- New Zealand needs to consider how to maintain and grow its own RSI capability, both in people and key infrastructure, rather than rely on offshore researchers and facilities. This growth should include support for the collection and maintenance of data, and RSI in the education and social sectors to ensure longer term social and cultural wellbeing.
- The RSI sector will play a pivotal role in helping New Zealand advance economic recovery over the coming years, especially in the areas of government priority (primary production, infrastructure, tourism, manufacturing and technology). Partnering with Māori will be critical to this endeavour. This activity also needs to include research and innovation to accelerate existing national priorities such as transitioning to a low carbon economy, improving environmental health, building social equity, embracing diversity, and better meeting Treaty obligations.
- The pandemic has highlighted the importance of research-based evidence in decision making. There is a need to ensure that future government policy development is also suitably evidence informed. Such development requires the appropriate weighting of that

evidence, together with the facility to interpret, interrogate and then implement policy based on that evidence.

- Implementation of COVID-19 control measures has emphasised the importance of quality data and data science and robust digital infrastructure, and the need for further investment in these areas within the RSI sector and government.
- Some of MBIEs current RSI investment instruments need to be reviewed to ensure that they maximise research effort, provide stable support for the RSI sector institutions, and meet the government's priorities for recovery. Instruments to accelerate the application and uptake of research by central and local government, Māori and industry need to be considered.

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