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Analysis of Access to Innovation Facilities

A Report for the Ministry of Business, Innovation and Employment, and the Ministry for Primary Industries

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1. Executive summary

We were asked to undertake an analysis of access to innovation facilities in the food and beverage, forestry and wood processing, and advanced manufacturing sectors. This analysis is designed to provide part of the evidence bases for development of the Food and Beverage, Advanced Manufacturing, and Forestry and Wood Processing Industry Transformation Plans.

During the innovation process, innovative firms often need support from existing research and innovation infrastructure. This includes the need for accessing research and innovation facilities and the expert knowledge that is associated with the relevant facilities.

Our review of the literature did not find many good examples of work done specifically on access to research and innovation facilities. Drawing from the EU review of the Danish research and innovation system Independent Experts Panel (2019) and the Irish KTI (2021), increasing costs and concentration in large enterprises, and IP ownership are becoming increasingly important themes. There were some additional key issues highlighted in guidelines from our search for literature on access to facilities. These sets of guidelines map key issues at a general level and could provide solutions to some of the prevalent problems faced in facilitating access to innovation facilities in New Zealand. We found little evidence of similar guidelines for New Zealand. Policy makers should consider creating similar guidelines and principles, where they do not have them, as part of better communicating with innovators when looking to improve access to innovation facilities.

The key takeaway from the stocktake of innovation facilities is that it is challenging to keep information relevant and up to date, and to present this information in a user friendly and accessible manner. As noted in our report, the innovation facilities encompass both physical assets (research space, equipment, instruments, and other physical assets) and people (expert knowledge and/or technical skills required to support the research and innovation process). This means some additional efforts need to be employed to improve visibility to external users of innovation facilities.

Our key findings are derived from the stakeholder engagement component of our analysis of access to innovation facilities. We conducted stakeholder interviews to assess current and future demand for access to New Zealand-based innovation facilities in the target sectors. The interviews were based around semi-structured questions exploring the insights from relevant stakeholders on the process of establishing a collaboration and/or commercial relationship between innovative firms and suppliers of innovation facilities.

Common across facilities were issues around accessing the required skills and expertise and how to best treat IP

Recommendations specific to each sector were centred around the speed and cost of the innovation process including potential gaps between pilot and scale up facilities

The key points for each recommendation below are in bold to help quickly direct the reader to the pertinent information in this section

> Forecasting the demand for access to innovation facilities in each target sector is very difficult, and in some sectors (e.g., advanced manufacturing) almost impossible to implement

We describe below our key findings for each relevant target sector.

Food and beverage

There are a variety of both publicly funded and private food and beverage innovation facilities available. Knowledge of these facilities and how to utilise them best tends to favour those with industry or technical backgrounds. The key facilities exist within the New Zealand Food Innovation Network (NZFIN), hosted across the country with links to research organisations and knowledge of commercial alternatives.

Stakeholders signalled multiple issues with access to innovation facilities within the food and beverage sector often relating to the speed of processes, costs, and the availability of knowledge or expertise.

The demand for innovation facilities is variable and given the COVID-19 disruptions an accurate picture of demand is not possible. However, stakeholders reported long wait time for certain facilities, particularly the FoodBowl and FoodPilot with wait times of 3 months or more reported.

A consideration to reduce wait time is some form of access price scaling. Costs that increase with the size and stage of the innovation process may incentivise innovators to transition faster from public innovation facilities to private alternatives or investments. Other options that move innovators on from high demand facilities faster would serve the same purpose of increasing the availability of space and expertise.

These high demand facilities are positioned at either side of a gap between pilot and scale-up facilities. Currently the facilities attempting to fill this gap are either too small (i.e. the innovator has outgrown the facilities) or are too large for the next stage of the innovation (i.e. the innovator is not able to fully utilise the capacity and capabilities). In absence of these facilities, innovators turn to the private sector and contract manufacturers which are often imperfect substitutes. Increased data collection effort centred around some basic access metrics such as referrals, flow of innovators, and exit reasons at innovation facilities may help to understand and address capacity issues.

The gap in suitable facilities appears larger for companies developing plant-based analogues (milks and meats). Typical innovation facilities are not capable or well-suited to support plant-based innovations. This is likely due to New Zealand's strong history in dairy and meat production and the resulting path dependency. Some stakeholders signalled they are attempting to fill the gaps privately for plant-based facilities and have some local government support.

Access to the physical facilities and equipment requires specialist knowledge. We heard that the dual mandates of universities and related facilities limit the capacity available for innovation partnerships. Responsibilities to teach and conduct academic research forces a trade-off with innovation projects. Publication-driven career development incentives at universities and related facilities cause a mismatch between facilities' wants and innovators' needs. Innovation projects tend to become large for the sake of publications rather than producing the bare-minimum to get to market as soon as possible. Necessary trade-offs between teaching, academic research, and innovation projects can extend the timelines for innovation projects.

Another challenging balancing act is the role NZFIN facilities have in directing and matching innovators with appropriate facilities, while also providing facilities themselves. This can create issues when considering the matching process, the capacity of facilities, and the incentives of facilities. Separating the responsibility for direction and matching from the operating of innovation facilities may improve the efficiency of the system.

Public funding acts as an enabler for access, however, it is generally limited in both opportunity and size. Funding from Callaghan Innovation Project Grants only cover up to 40 percent of R&D which can leave small innovators to front proportionately large and prohibitive costs to be able to access innovation facilities. Callaghan Innovation paused the popular project grants for 2021 which created a waitlist for applications – innovators that rely on this funding as a critical enabler for access have been forced to deal with drawn out timelines. At the time of writing the grants have been restarted.

Facilities have different approaches to IP dependent on their mandate which can cause access issues. Many stakeholders were concerned about how innovation facilities manage IP and feared that despite innovators having "ownership" of the IP, it was likely being used and shared with other innovators. As a result, some innovators are reluctant to access innovation facilities. Stakeholders suggested there is competition in foundational research/innovation, with innovators individually contributing significant resource to conduct basic science with no IP outcomes. Overall, this may be limiting the success of innovators since it requires significant resource and takes away from other innovation activities. A government focus on cooperative, open source, foundational research with shared IP could allow innovators low-cost access to foundational knowledge and allow innovators to use their limited resources in more efficient ways (i.e. in the next steps of the innovation process).

There is high demand for pilot and scale-up facilities which is causing wait times of up to 3 months. Stakeholders reported a gap in provision between pilot and scale-up facilities with this gap appearing to be larger for products not centred around the meat and dairy heritage. Access is highly dependent on linked skills and expertise which those new to food and beverage innovating struggle with.

Advanced manufacturing

Most innovation facilities (including research expertise) within the advanced manufacturing sector sit within universities or are associated with universities. Stakeholders (both providers and users of innovation facilities) within the advanced manufacturing sector have signalled multiple issues exist with access to public innovation facilities.

Overall, speed of the process that establishes a commercial relationship between businesses (i.e., innovators) and providers of innovation facilities has been raised as a key issue. Innovators are often unable to get work done in the time frames they require due to capacity constraints or lack of commercial incentives at innovation facilities that are located within universities. This is partly driven by researchers' dual mandates and responsibilities, where teaching and academic research is being prioritised over commercial innovation engagements. There may also be a systematic lack of capability in some niche areas of advanced manufacturing due to the size and, potentially, lack of comparative advantage in New Zealand.

Researchers' career development incentives based on publication outputs can cause commercial innovation projects to last much longer than the innovator desires (i.e., gold-standard outcomes rather than minimum-viable-products to go to market). Commercially focused career development opportunities within universities may, therefore, help to address this barrier to efficient collaboration between researchers and businesses. This should increase the existing capacity at innovation facilities and speed up some of the innovation process undertaken by innovative firms.

Another impediment observed with New Zealand-based innovation facilities is the lack of public awareness of capacities and capabilities (e.g., expertise and functionalities) that exist within the innovation facilities in the advanced manufacturing sector in New Zealand. Successful commercial innovation collaborations are often established through networking (i.e., personal connections), which means some innovators have difficulties in finding the right facility that can support their innovation projects.

Other issues raised by stakeholders are around education of innovators and facilities for costing and IP management, and as such there exists an opportunity for the government to invest in educational resource. Also, inappropriate IP management within innovation facilities can lead to a lack of trust and can create a distorted image of a public-private innovation partnership, particularly with small innovative firms and/or start-ups.

Finally, there are also further research opportunities for the government regarding structural labour market shortages in advanced manufacturing, scale-up facility gaps, and ways to increase and socialise facilities and capabilities between providers and innovators.

Forestry and wood processing

The two key (largely) government funded innovation facilities in the Forestry and Wood Processing target sector in New Zealand are Scion and the University of Canterbury – the College of Engineering, the School of Forestry, and the Wood Technology Research Centre. There also exist a few additional fringe forestry research facilities, though interviewed users reported only using Scion and the University of Canterbury.

The key government intervention that supports access of Scion's innovation facilities, as is the case for the other CRIs, is through a mix of core funding (from the Strategic Science Investment Fund, SSIF), contestable funding and contracts with government agencies. Scion's funding share from government is above the average level of the seven CRIs as its funds 79 per cent of Scion's revenue which totalled $61.08 million in 2021. The University of Canterbury is the second major innovation facility in the forestry and wood processing sector. The University offers an alternative research option to Scion and is the only university in New Zealand that offers professional forestry degree programmes. Public funding for its research is primarily through the Performance Based Research Fund.

The sector's stakeholders reported a range of issues with accessing these innovation facilities, with some of these common across sectors, and others unique to forestry and wood processing.

New Zealand is likely to be missing out on innovation potential because of the difficulties smaller and newer firms have with accessing innovation research and facilities. To change this situation the government could consider policy options that aim to change Scion's appetite to prioritise new or smaller firms. This could include restructuring or repurposing existing funding options for innovative firms in the sector, such as the Sustainable Food & Fibre Futures fund, or creating a new special purpose fund, that seek to select promising new forestry innovations from SMEs that require further development by research facilities such as those at Scion or the University of Canterbury.

Another option to assist new and smaller firms in accessing innovation facilities would be to create a position for a front person or relationships manager to help them find the right help with their innovation development ideas. Such a person could act to direct inquiries to the right people within the innovation facility. This is probably best done by each innovation facility rather than across innovation facilities because such a relationships manager must be fully au fait with personnel and capabilities of the facility. When such a role covers multiple innovation facilities, it is very challenging for that person to stay up to date with all the personnel and capabilities.

There is a distinct lack of a scale up facilities in the sector. Scion is pursuing an initiative to explore the potential for a bio-pilot plant. This would take the form of a pre-commercial production facility. It would use technology to produce small/medium level volumes products, mainly for the purpose of learning about the new technology or product. The idea is that a bio-pilot plant would de-risk this learning for innovators in the bio-products sector. We recommend the government should carefully consider the value of a bio-pilot plant for the forestry sector. This would require, as has been the case for such initiatives in the food and beverage sector, a detailed assessment of likely demand and for production of the product set such a plant would be capable of providing. Our analysis found some demand for such an approach from some interviewees.

Our interviews highlighted there needs to be a greater focus on solving industry problems as Scion had not communicated very effectively with its stakeholders. However, this view appears to be based on Scion's approach in the past rather than its current approach in which it has prioritised its communication efforts. Bearing this in mind, government should encourage Scion to continue and build on its strategy of improving its communications and interactions with the forestry sector and other stakeholders. Scion's recent strategy appears to have been welcomed by the industry and is seeking to maximise the value added to New Zealand.

2. Introduction

In 2019 the New Zealand Government launched a new approach to industry policy, aimed at growing more innovative industries in New Zealand and lifting the productivity, sustainability and inclusivity of key sectors in the New Zealand economy (the Industry Strategy).

The government assessed the target sectors for the Industry Strategy, based on the following criteria:[1]

- The sector is important for New Zealand's transition to a low emissions economy.
- There are opportunities to move from volume to value and/or to diversify.
- New Zealand has some comparative advantage to draw on.

The Industry Strategy sets out a partnership-led approach to industry policy through the development of Industry Transformation Plans (ITPs). ITPs focus on transforming industries by either lifting productivity or growing their value where New Zealand has some comparative advantage.

Seven broad sectors (target sectors) have been chosen with this objective in mind: food and beverage, forestry and wood processing, advanced manufacturing, agritech, digital technologies, construction, and tourism.

ITPs have been developed for the agritech and construction target sectors, and are currently in development for digital technologies, tourism, advanced manufacturing, food and beverage, and forestry and wood processing.[2]

One of the core guiding principle for the ITPs is stated as:[3]

> Building and using a strong evidence base to guide our focus and interventions, including robust evaluation and monitoring.

In line with this guiding principle, this report has been developed to provide the insights and evidence base about the role, value and demand for access to innovation facilities in the following target sectors:

- Food and beverage
- Forestry and wood processing
- Advanced manufacturing.

[1] https://www.mbie.govt.nz/dmsdocument/5949-refocusing-our-approach-to-industry-policy-proactiverelease-pdf
[2] See more about the progress made in the Industry Strategy at https://www.mbie.govt.nz/business-and-employment/economic-development/industry-policy/
[3] https://www.mbie.govt.nz/dmsdocument/5949-refocusing-our-approach-to-industry-policy-proactiverelease-pdf

In this report, the following meanings are given to the innovation facilities in the above target sectors:

Food and beverage target sector – all New Zealand-based innovation facilities that support the transformation towards higher value in the entire value chain encompassing all land-based and marine food and beverage products that are intended for human consumption.

Forestry and wood processing target sector – all New Zealand-based innovation facilities that support the transformation towards higher value in the entire forestry and wood processing supply chain from nurseries, through forest owners, to current wood processors and manufacturers, including the wood bioenergy subsector.

Advanced manufacturing target sector – the New Zealand-based innovation facilities that support the implementation of new or significantly improved goods and products, regardless of the technological level observed in the manufacturing sector (excluding the manufacturing activities in the food and beverage and wood and processing target sectors).

We conducted desktop research of the literature available on the role and value of innovation facilities, and issues around accessing such facilities.

We conducted semi-structured interviews with key stakeholders and other relevant parties, as identified in the inception meeting and as developed in the project plan. All interviews were held by telephone or videoconference. We used our contacts to ensure that we explored a wide set of views, including those of firms also developing and implementing alternative strategies and capabilities, and industry insiders not necessarily involved or engaging with innovation facilities in scope.

3. Research on issues around access to innovation facilities

We conducted a literature review of research papers and reports relating to innovation facilities. The review places this report in context by identifying key features of New Zealand's innovation ecosystem. We examine international literature to note key issues with access to these facilities and the best practice guidelines developed in response.

3.1 New Zealand's innovation landscape

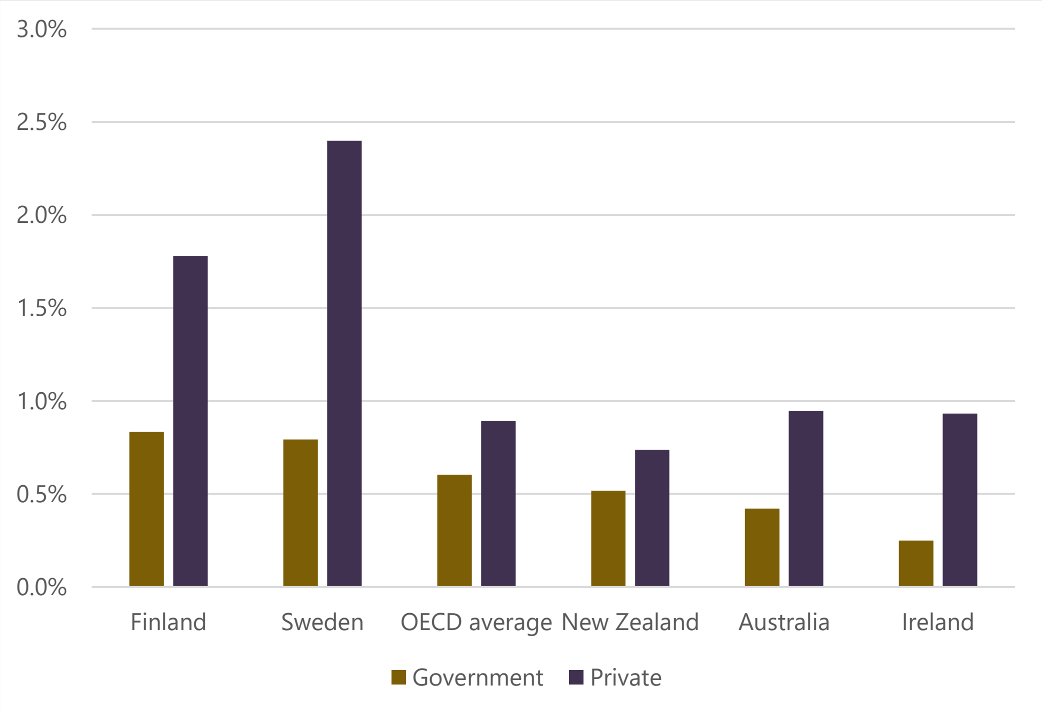
The following section examines New Zealand's innovation landscape by putting the New Zealand ecosystem in a global context and by looking at current interventions that support access to innovation facilities.

3.1.1 New Zealand's innovation ecosystem

An innovation ecosystem is defined as the wide range of factors, either directly or indirectly, that impact on a firm's innovation. New Zealand's innovation ecosystem includes the networks between firms, people, and the New Zealand Government that together shape the rate and direction of innovation. Government support in the ecosystem, e.g. funding a research institute, will help to overcome the tendency of firms to underinvest, and therefore to realise the positive externalities associated with innovation investment (New Zealand Productivity Commission, 2021).

We briefly look at New Zealand's innovation expenditure relative to similar small advanced economies (SAEs) in the OECD to give context to New Zealand's innovation ecosystem.

Figure 1: Government and private expenditure on R&D, 2017 (% of GDP)



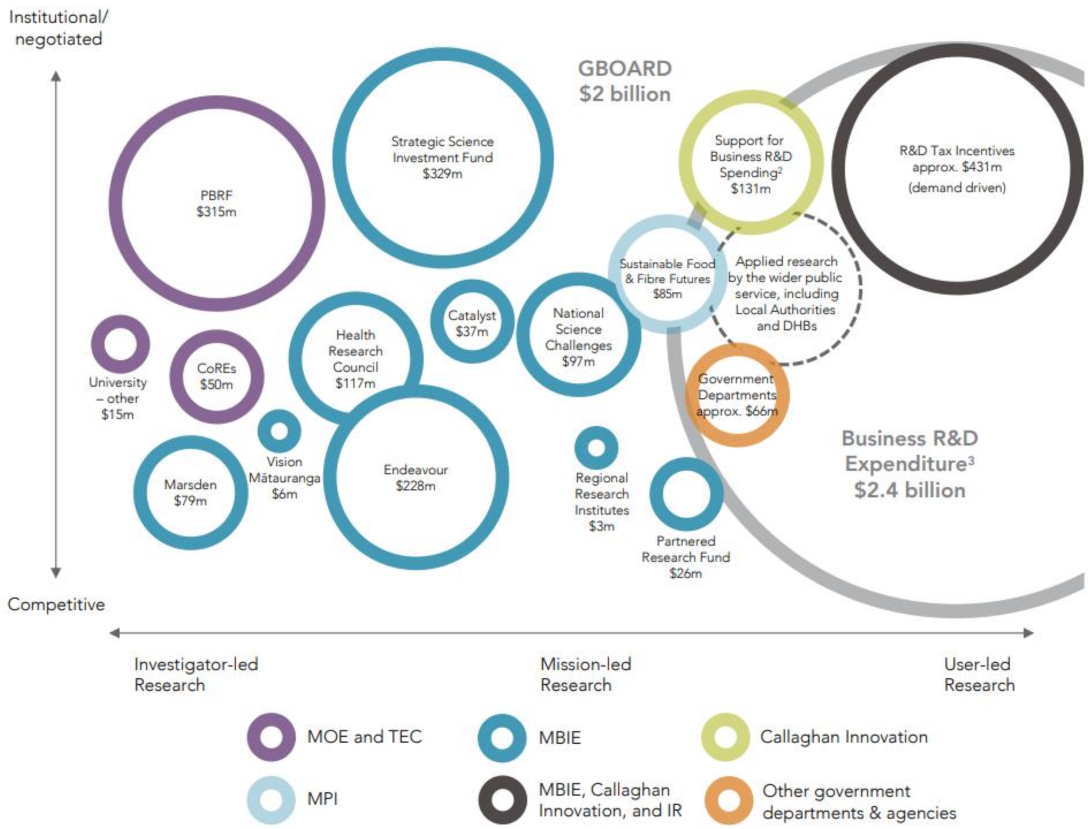
Source: OECD.Stat: Government budget allocations for R&D, OECD Data: Gross domestic production

Figure 1 compares New Zealand's government and private spending (relative to GDP) on research development with other SAEs in the OECD, as well as the OECD averages. Though New Zealand has greater government spending than Australia and Ireland, it has the lowest private expenditure out of the SAEs shown. This observation suggests that while not the lowest, there is potential for research and development expenditure to increase.

3.1.2 New Zealand's government interventions that support access to innovation facilities

New Zealand's public funding of $2 billion for research, science, and innovation is split into many funds. These are displayed in the following diagram:

Figure 2: Funding for research, science, and innovation 2021-22



Source: New Zealand Productivity Commission 2021

The horizontal axis shows funding based on the source of the ideas, i.e. investigator-led explores scientists' ideas, user-led explores businesses' ideas, and mission-led falls between the two. Conversely, the vertical axis shows the method of funding allocation, i.e. contestable or allocated to institutions. The most notable of these funds include the R&D Tax Incentives (RDTI), the Strategic Science Investment Fund, and the Performance Based Research Fund (PBRF).

The RDTI aims to stimulate innovation by firms and raise productivity by offering a tax credit. Tax credits are aimed at incentivising firms to develop applications with the potential to be brought to market within a reasonable timeframe (OECD, 2021). The Strategic Science Investment Fund provides the core funding of the seven Crown Research Institutes (CRIs). The PBRF is the government's primary means to fund Tertiary Education Organisations (TEOs), with universities attracting around 96 per cent of this funding (New Zealand Productivity Commission, 2021).

A detailed list of all funds presented in Figure 1 can be found in Appendix A.

In addition to CRIs and TEOs, the public funding contributes, both directly and indirectly, to Callaghan Innovation, the Centres of Research Excellence (CoREs), the National Science Challenges, and a few smaller research and commercialisation institutions.

- CRIs are Crown-owned companies that carry out scientific research for the benefit of New Zealand, aiming to achieve economic growth through improved productivity and

improving the sustainability of resources (MBIE, 2021). CRIs are funded through the SSIF, contestable funding, contracts from government agencies, and private investment.
- TEOs undertake research that has the potential to lead to innovation by firms, or research that directly supports innovation. In addition to PBRF funding, government (through contestable and departmental funding) and the private sector fund another $500 million (PBRF Review Panel, 2020).
- Callaghan Innovation is a Crown entity attributed as New Zealand's Innovation agency. Callaghan's service include connecting businesses to relevant providers and partners, providing in house R&D, and fostering initiatives to improve innovation ecosystems (New Zealand Productivity Commission, 2021).
- CoREs were established in 2001 as a means to increase resources for areas of research strength in New Zealand, enabling concentrated research effort in academic disciplines. There are currently 10 cores with a mix of mission-orientated research and research focused on innovative enabling technologies (New Zealand Productivity Commission, 2021).
- The 11 National Science Challenges were developed in 2014 to address the largest science-based issues and opportunities for New Zealand. The challenges bring together New Zealand's top scientists to work collaboratively. Funding for these amounts to $680 million over 10 years (MBIE, 2021).
- Public innovation funding has also contributed to other research and commercial institutions outside of these main entities, e.g. the four Regional Research Institutes, aimed at deepening R&D intensity in areas of comparative advantage, or the Food Innovation Network (NZFIN), a network of four open-access food and scale-up facilities aimed at developing and commercialising value-added food and beverage products (New Zealand Productivity Commission, 2021).

These funds and entities represent the primary government interventions designed to assist access to innovation facilities in New Zealand.

3.2 Literature on access to innovation facilities

The level of access to innovation facilities is a key determinant of their overall effectiveness. We found evidence of overseas initiatives that have been launched to address issues with access, aiming to promote innovation and bridge the gap between innovation and commercialisation. The following section examines some of these issues and identifies examples of best practice guidelines developed internationally.

3.2.1 There are several issues constraining access to innovation facilities

The literature highlighted a number of key trends in access to innovation facilities globally:

- increasing costs of research and development (Independent Experts Panel, 2019)
- increasing concentrations in large enterprises (Independent Experts Panel, 2019)

- the ownership of intellectual property (IP) (KTI, 2021).

Increasing costs have been highlighted across multiple studies as an issue. Ireland released a set of national guidelines on access to research infrastructure (HEA, 2021). It stated that in the 21st century, modern research infrastructure is increasingly complex and specialised, therefore becoming increasingly expensive. Not only do increasing costs act as roadblocks to scientific discovery (HEA, 2021), but they limit access to only those with wealth.

The increased concentration of private innovation effort in large multinational companies can prevent small and mid-size enterprises (SMEs) from accessing innovation facilities. The difficulty in access can be attributed to costs and knowledge access barriers. Lack of knowledge is increasingly documented as an issue in accessing innovation. The League of European Research Universities (2017) states transparency on research infrastructure access policies is of particular importance for SMEs – with SMEs being important because of their largely untapped ability to enhance scientific excellence and promote collaboration in modern research (LERU, 2017). This concept is relevant to New Zealand. There are limited access policies and information on access available, meaning knowledge barriers can exist and hinder access to innovation facilities.

There is also a documented IP issue. IP rights are a major means for entities to appropriate the value of the inventions (WIPO, 2015). As such, the ownership of IP can often be an area of contention between firms and research performing organisations. Firms can think they are entitled to the IP as they funded the research, whereas researchers can think they own it given they undertook the work. Rights to the IP allow for the commercialisation of results (WIPO, 2021); however, they limit use of the IP by competitors. These pressures around how IP is treated has been reflected in the interviews undertaken for this report. As stated by the Productivity Commission (2021), to maximise innovation, IP protection must strike a balance between providing rewards to innovators and not hampering the dissemination of new technology.

To address the IP issue, Knowledge Transfer Ireland (KTI) released the KTI Practical Guide to Managing Intellectual Property and Confidentiality. The Guide aids understanding and planning of common IP issues, helping commercial arrangements between companies and Irish research performing organisations to be reached. Specifically, the guide explains the different types of IP and how they can be generated, methods to protect the IP, confidentiality considerations, and commercialisation of the IP (i.e. how it can be used to generate payment). These guidelines could be applied to a New Zealand context. To maximise the opportunities in the innovation ecosystem, intellectual property laws should be clear, and where possible, arrangements should be flexible to suit all stakeholder needs.

3.2.2 Best practice guidelines for access to research infrastructure

There is evidence of recent efforts to encourage access to research infrastructure overseas. It is widely recognised that there are significant benefits for the economy and society from improving access to research infrastructure. This section examines initiatives aimed at promoting improved access and international examples of best practice guidelines for accessing research infrastructure.

The European Commission's Joint Research Centre (JRC) summarises the benefits to users of expanding access to the JRC:[4]

- Access to JRC research infrastructures, based on open calls for competitive access, will allow European users not traditionally engaged with the JRC to have access through a transparent procedure. Research infrastructures attract talent and stimulate innovation and development. Enabling access to the JRC research infrastructures will enhance competitiveness, through pre- and co-normative research, and will contribute to bridging the gap from research to industry, e.g. through the setting up of demonstration projects for product validation.
- Access of users to JRC research infrastructures contributes to the dissemination of knowledge, improves related methods and skills, provides education and training, and fosters collaboration at European level.
- Granting access within a structured framework will maximise the return on taxpayer-funded investment that the JRC has made on its research infrastructures, making them available to external users in view of the limited resources now existing in Europe.

The European Charter for Access to Research Infrastructures (2016) released best practice guidelines for access to research infrastructure. The Charter sets out non-regulatory principles and guidelines to be used as a reference when defining access policies for research facilities. The guidelines aim to maximise these facilities' return on investment by driving innovation, competitiveness, and efficiency using the scarce resources available (European Commission, 2016).

These include:

- Access policy – research facilities should have a transparent policy defining how they regulate, grant, and support access to (potential) users from academia, business, industry, and public services.
- Acknowledgement and co-authorship – users should acknowledge the contribution of the facility in any output (e.g., publications). In accordance with scientific practice, users are encouraged to offer co-authorship to those at the facility who made genuine scientific contribution to their work.
- Legal conformity – facilities should comply with national and international law and agreements, particularly for areas of IP rights, protection of privacy, ethical considerations, safety, security, and public order regulations.
- Costs and fees – costs need to be covered, and where necessary, fees for access should contribute to the financial sustainability of the facility.
- Ethical conduct and research integrity – facilities and users should adhere to the standard codes of conduct and ethical behaviour in scientific research.
- Non-discrimination – facilities should not discriminate on personal grounds. Equal opportunity policies should be considered.

[4] https://ec.europa.eu/jrc/en/research-facility/open-access

- Implementation – administration for requesting and granting access to facilities should be kept to a minimum.
- Research data management – facilities should have a research data management policy that ensures research data are appropriately maintained, archived for a reasonable period, and available for review and reuse. If appropriate, facilities should consider open access to research data.
- User instruction – facilities should provide users with instructions, access to expertise, and training for effective and efficient access to facilities.

While being quite general, these principles should help to improve access to research and innovation.

The Irish HEA (2021) also released guidelines for access to research infrastructure in Ireland. The guidelines aim to facilitate access to research infrastructure to maximise return on investment for the Irish state and for the research community in general. Similar to the European Charter for Access to Research Infrastructures guidelines, these may be adapted and used in a New Zealand setting to improve access to innovation facilities.

The guidelines set out requirements to ensure proper access to research infrastructure, including:

- open and transparent access policies
- auditable access cost basis
- proper record keeping, including records of access requests and, where relevant, decisions and reasons in the event of a refusal, usage data, etc
- proper service and maintenance contracts in place, where relevant
- support staff who can operate the research infrastructure and assist in the training of postgraduate students and other researchers.

HEA (2021) states that without these guidelines, Ireland's access to these recent investments would be restricted and the economic benefits limited.

3.2.3 An example of international government intervention to improve access in forestry and wood processing

The European Union funded ERIFORE project aims to facilitate the transformation to a circular forest bioeconomy by developing an open-access distributed research and innovation infrastructure.[5] The project hopes to bridge the gap between science, innovation, and commercialisation to optimise the use of forest biomass (CORDIS, 2018).

ERIFORE facilitated the multidisciplinary European Strategy Forum on Research Infrastructures (ESFRI) to promote innovation. The Forum identified a strategy to promote access to research facilities, stating research infrastructure should avoid duplication of efforts, pool resources, rationalise research facility use, standardise processes and procedures, and consolidate leadership. The strategy involved extensively mapping research needs and drivers, the availability and development needs of existing

[5] ERIFORE – the European Research Infrastructure for Circular Forest Bioeconomy.

research infrastructures, and the collaboration required in the circular forest bioeconomy (CORDIS, 2018).

We note we were unable to find similar international examples in the food and beverage and advanced manufacturing literature.

3.3 Conclusion of literature review

There are many New Zealand Government interventions aimed at promoting innovation as seen in Figure 2. This public expenditure is combined with private expenditure to fund innovation by firms, much of which uses New Zealand's government-funded innovation facilities. This is a core part of New Zealand's innovation ecosystem, assisting innovation to ensure the economic performance of New Zealand is sustainable.

Our review of the literature did not find many good examples of work done specifically on access to research and innovation facilities. Drawing from the Independent Experts Panel (2019) and KTI (2021), increasing costs and concentration in large enterprises and IP ownership are increasingly important themes. There were some key issues highlighted in guidelines from our search for literature on access to facilities. These sets of international guidelines map key issues at a general level and could provide solutions to some of the prevalent problems faced in facilitating access to innovation facilities in New Zealand. We found little evidence of similar guidelines for New Zealand. Policy makers should abide by these guidelines and principles when looking to improve access to innovation facilities.

4. Food and beverage sector

There are multiple government interventions within the food and beverage industry that enable access to innovation facilities and expertise.

The primary source of government intervention is through the funding of the Food Innovation Network to enable open access facilities. Some of the funding from the government to the Food Innovation Network was historically for capital investment into new facilities:

- $3 million investment into FoodWaikato wet processing facilities in 2014. Callaghan Innovation funding contributed to a $5 million upgrade of FoodWaikato's open-access pilot manufacturing facility in Hamilton.[6]
- $5 million over five years from 2015 into the Food Innovation Network – building of FoodSouth food innovation centre and pilot production plant at Lincoln University.[7]
- $9.57 million over two years from 2019 to Food Innovation Network, directed at FoodBowl and FoodSouth.[8]

In 2015 MBIE funded the Regional Research Institutes Initiative to benefit regions outside main population centres, and support and further enhance regional advantage in NZ by stimulating leading-edge, industrially exploitable and commercially focused research. This programme is now closed.

4.1 Stocktake of innovation facilities

The information below (and listed in Appendix B) was sourced from organisations' websites, interviews with key people, and, where possible, email correspondence.

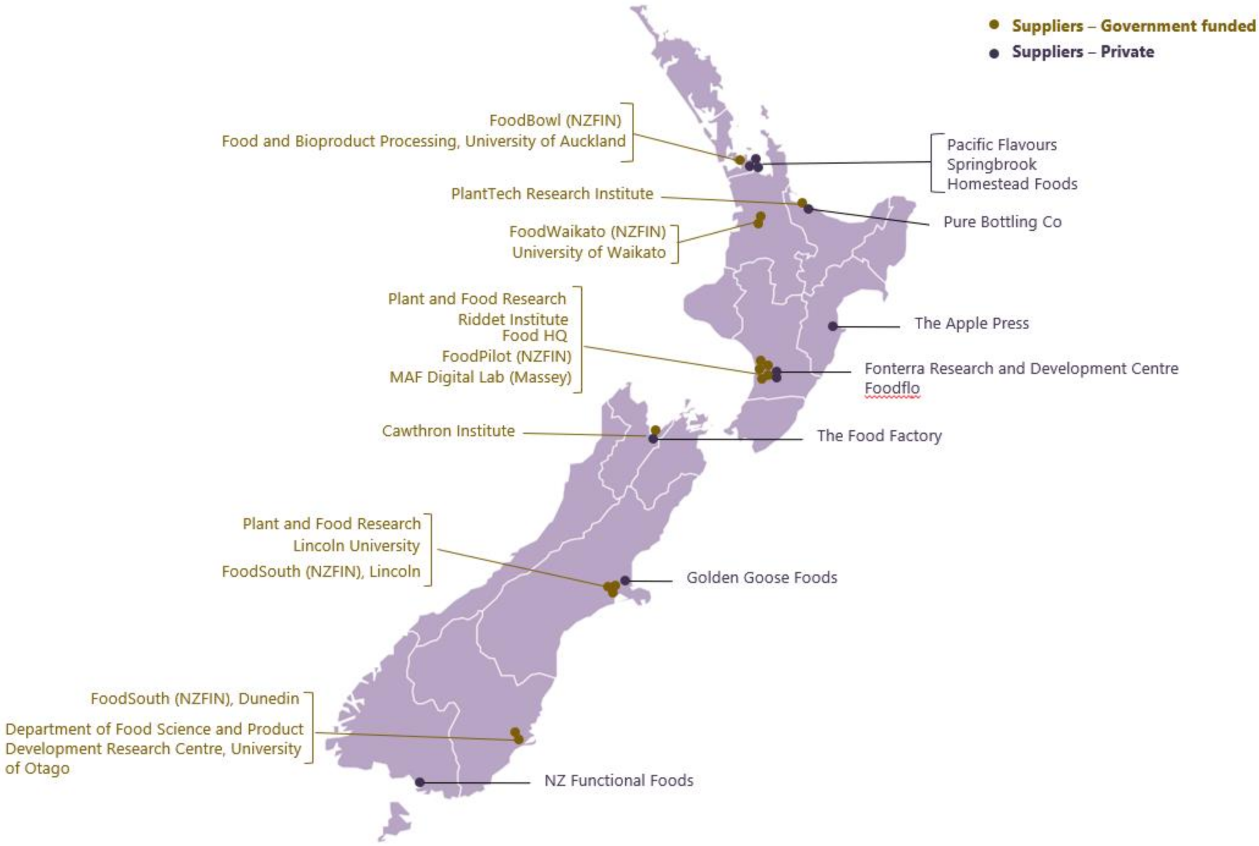
Limitations:

- Information on websites regarding facilities, equipment, expertise, and the type of service offered to businesses, if any, was variable and inconsistent. Some organisations listed all equipment and facilities, whereas others were vague about the type of service provided. Many organisations offered expertise and knowledge but were not clear whether this included the use of facilities and equipment.
- It is often not clear to those with limited experience or non-technical backgrounds whether the facilities are worth contacting.
- Pricing was not transparent in most cases. To find out costs involved in using the organisation's services, a business usually needs to contact the organisation and discuss the project they are undertaking.

[6] https://www.callaghaninnovation.govt.nz/news-and-events/callaghan-innovation-boosts-value-added-food-production-waikato
[7] https://www.callaghaninnovation.govt.nz/news-and-events/5m-expand-food-innovation-network
[8] https://www.callaghaninnovation.govt.nz/news-and-events/budget-2019-innovation-and-high-value-tech

- It is not clear at what point during product development that the organisation will be most useful for innovative businesses, i.e. whether during the initial testing phase, development, pilot, or scale-up.
- Many organisations work together collaboratively, so it is not clear whether their listed facilities are their own or simply those they have access to.

Figure 3: Map of food and beverage providers



4.1.1 The Apple Press

The Apple Press is a private company producing cold-pressed juices at its production facility in Whakatu, Hawke's Bay. The company has won awards for its innovative juice products. Its facilities are not available to the public.[9]

It is not clear what services (expertise or facilities) the Apple Press offers to food companies.

4.1.2 Cawthron Institute

Based in Nelson, the Cawthron Institute and Aquaculture Park is a research and technology centre for the New Zealand aquaculture sector and its stakeholders. It is a shared facility, purpose-built for aquaculture research, education and commercial development. Land units are available to lease for

[9] Sally Gallagher, personal communication, November 2021.

aquaculture activities. Cawthron undertakes government-funded aquaculture research as well as research and innovation for industry and primary sector groups. Its product development services include:

- validating nutritional content
- testing for toxins in seafood
- resource management advice.

Cawthron does not have a price list for use of resources or specialist advice. Cawthron discusses first with potential clients what they need and how the organisation may be able to help them, followed by pricing discussions.[10]

See Appendix B for details of Cawthron's research centres and laboratories.

4.1.3 Fonterra Research and Development Centre

Fonterra's Research and Development Centre is a large facility based in Palmerston North, with around 280 scientific and technical staff. FRDC is home to over 130 PhDs and 350 dairy patents.[11]

Fonterra also provides limited third-party manufacturing services including expertise, packaging facilities (product blending facilities, can assembly machines, can filling lines and sachet packing machines), and manufacture of consumer format dairy products.[12]

4.1.4 Foodflo

Foodflo International is a privately owned contract manufacturer, based in Pahiatua. The company supplies quality food inclusions for food manufacturers. The standard minimum order quantity is 200 kg, but they provide some flexibility for launches and trials.

Within their product offering, they are open to size, flavour, shape and texture changes based on the needs of the particular development brief. They can also offer products to suit specific dietary requirements such as gluten free, dairy free, vegetarian, vegan, halal and organic.

The company states that the lead time for an inclusions order is four weeks for New Zealand orders.

4.1.5 Food HQ

FoodHQ is an open collaborative partnership involving most of New Zealand's capability in food science-based innovation, and includes public and private sector research, education and industry organisations. It is headquartered in Manawatū with extensive national and international networks.

FoodHQ works with innovators to assist them in accessing scientific expertise and physical infrastructure by supporting them to navigate the ecosystem and access key facilities and personnel.

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[10] Robert Matheson, personal communication, November 2021

[11] https://www.nzmp.com/global/en/about-nzmp/innovation-and-ingenuity/the-fonterra-research-and-development-centre.html

[12] https://www.nzmp.com/global/en/products/nzmp-solutions/third-party-manufacturing.html

4.1.6 Golden Goose Foods

Golden Goose Foods in Christchurch is a contract manufacturing company specialising in battered products such as hotdogs, including vegan and gluten-free products. It offers house-branded products and customised items for chain store menus. Golden Goose can hand-batter or machine-batter batch lots from 100kg to several tonnes.[13]

4.1.7 Homestead Foods

Homestead Foods is a privately owned contract manufacturer, based in Auckland. Homestead Foods offers a range of hi-spec and innovative food manufacturing, processing and packaging solutions. The company's business operations, with its core of experienced staff and extensive processing facilities, is focused on innovation and best practice food manufacturing processes. Along with the production of an extensive range of foodservice sauces, dressings and syrups in traditional packaging styles, Homestead Foods capabilities have been extended with the addition of a hot fill pouch packing line with post pasteurisation along with a range of portion control packaging equipment.

4.1.8 Lincoln University's Centre of Excellence – Food For Future Consumers

The Centre of Excellence – Food for Future Consumers is a research centre based at Lincoln University in Canterbury. The centre focuses on academic research into provenance, food quality and consumer demand/preferences.[14]

It is not clear whether the centre works directly with food and beverage firms to develop products, other than benefiting from research undertaken, and no information is available on the centre's website.

4.1.9 The Food Factory

The Food Factory, based in Nelson, is a not-for-profit food innovation centre developed by Pic Picot of Pic's Peanut Butter with funding from the Provincial Growth Fund. It is in the process of applying for status as a charitable trust for educational purposes.

The Food Factory offers a variety of equipment and facilities for making, packing and storing food (see Appendix B), training in their use, and expertise on food safety, funding and business basics. The Factory can connect clients to a network of industry experts.[15] Most of the information is readily available on the Food Factory's website.

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[13] https://goldengoose.co.nz/contract-manufacturing/

[14] https://research.lincoln.ac.nz/our-research/faculties-research-centres/centre-of-excellence-food-for-future-consumers

[15] https://www.thefoodfactory.co.nz/the-deal

4.1.10 New Zealand Food Innovation Network (NZFIN)

NZFIN is a government-funded network with locations in Auckland, Waikato, Palmerston North, Lincoln and Dunedin. It offers consulting services from start-up, to scale-up, commercialisation and export.

See Appendix B for more details on capabilities, facilities and equipment.

FoodBowl

FoodBowl enables innovative start-ups, SMEs, corporates and network partners to develop, scale up and commercialise new products. FoodBowl has six separate food and beverage manufacturing suites for hire to clients, offering over 300 pieces of equipment which are configured to specific client needs. FoodBowl has an RMP which allows products to be manufactured and exported. Advice, connections, engineering support and training is offered.

Process capabilities include high-pressure and general processing, packaging, liquids/beverages, freeze-drying, dry processing and certification.

FoodWaikato

FoodWaikato focuses on development and commercialisation of new industry and to increase New Zealand exports. It offers specialist milk spray drying capability and business support to food and beverage companies.

The facility was built in Waikato to service the growing sheep and goat milk industry which was concentrated there. Because the non-bovine milk market was still emerging, there was a lack of sufficient capital and confidence in the market demand for any one individual company to build their own facility. It is important to note that if FoodWaikato was to operate on a purely commercial basis, it would target optimal utilisation for minimum effort, which would result from focusing on the now established companies in sheep and goat milk. However, because it has a significant government ownership and a mandate to support innovation and the development of new businesses, it has instead required all businesses to vacate FoodWaikato after they have reached particular milestones in order to free up FoodWaikato capacity to allow for new firms to enter. It has also recently helped several larger firms build a neighbouring fully commercial facility for those firms to jointly use, which FoodWaikato will continue to provide operational support to. FoodWaikato has a small shareholding in this new facility as a reflection of the value of the IP it has contributed to its design and the value of its ongoing support.

FoodPilot

FoodPilot is an open-access facility run by Massey University. It is part of both the NZ Food Innovation Network and FoodHQ. FoodPilot houses the R&D centre for several private companies and supports research and development work undertaken by Massey, AgResearch and the Riddet Institute, ranging from the more fundamental through to commercially focused. Its processing capabilities include evaporating and drying, chopping and mincing, cooking and process control, extrusion and puffing, and certification.

The facility is a 1,800m^2 pilot plant building with food process equipment housed among chillers, freezers, and storerooms. It is organised into pressure-controlled product zones and carries the registrations to make product for sale or consumption in New Zealand or for export. Equipment is R&D scale (typically 30-300 kg batches or 10 – 100 kg/hr), and it has a fully equipped 200 L microbrewery. The FoodPilot is supported by people and equipment for sensory and consumer insighting work, for shelf-life trials and for nutritional testing, for imaging, characterisation and analysis of product.

FoodSouth

FoodSouth is an open-access facility based at Lincoln University, with additional facilities at the University of Otago. It has three processing rooms with a range of unit operations available, including drying, extrusion and UHT (20-200L batch size), with specialists in plant-based milks and meat analogues. Partnership with University of Otago (FoodSouth Otago) enables access to further equipment.

4.1.11 New Zealand Functional Foods

NZ Functional Foods is a private company based in Invercargill. As well as being a contract manufacturer, it helps companies to "develop, match, test and certify a wide range of products". It specialises in oat milk products and other plant-based milks. Capabilities include desk research, ingredient sourcing, benchtop development, enzymatic hydrolysis, pilot production and small-scale commercial production. NZ Functional Foods offers access to a network of research and development experts in New Zealand and internationally. It has links to NZFIN, Otago and Massey Universities, Plant and Food Research, and other food companies and consultants.

NZ Functional Foods has an innovation line for liquid products that allows small commercial pilots and production runs in SIG cartons, which allows companies to "innovate and try new formulations, products and packaging without having to do a full-scale production run". It also has a high-speed line that can deliver 12,000 units per hour.[16]

4.1.12 Pacific Flavours and Ingredients

Pacific Flavours and Ingredients is a privately owned contract manufacturer, based in Auckland. The company states that its network of suppliers, manufacturers and marketers gives the company the ability to provide customised, one-solution experiences for its customers. The company states its focus is the representation, import and technical support for a range of high end "international" ingredient products which are currently sold into various food manufacturing sectors (e.g., meat, dairy, beverage, confectionary & nutritional) in New Zealand and Australia. As well as representing some large international multinational food ingredient producers, the company states that it has now started construction on a dairy rated production facility for both powdered and liquid flavours, which will give the company the ability to offer small to large order requirements to its entire client flavour base. The

[16] https://nzfunctionalfoods.co.nz/innovation/

company also states that it is a dominant supplier of various proteins to the meat and nutritional industry.

4.1.13 PlantTech Research Institute

In Tauranga, PlantTech is a research and development organisation backed by a consortium of primary sector groups, technology/digital firms, local businesses, and the University of Waikato.

PlantTech develops new AI, machine learning, and data science capabilities for the primary sector, including horticulture and agriculture. The offering is predominantly in R&D expertise along with IP/knowhow that can be leveraged into solutions. PlantTech supports R&D piloting, trialling, testing, and scale-up, but not primarily through physical buildings, spaces, infrastructure or equipment.[17]

4.1.14 Pure Bottling

Pure Bottling is a privately owned contract manufacturer, based in Tauranga. The company has the capacity to supply small to large businesses that are looking for a partner who can contract manufacture and/or bottle and label a wide variety of liquid goods. They provide assistance in developing final product recipes, sourcing bottles and labels, packing and distributing throughout New Zealand.

4.1.15 Riddet Institute

The Riddet Institute is a national centre for scientific research in food. Its area of expertise is at the intersection of food material science, novel food processing, gastrointestinal biology and human nutrition. With locations throughout New Zealand, it partners with Massey University, AgResearch, Plant and Food Research, the University of Auckland and the University of Otago.

The institute is headquartered at Massey University in its new building, Te Ohu Rangahau Kai, which opened in 2020. Over 150 scientists work at the facility, which has 2,500m^2 of laboratory and pilot space. Its capabilities include physical chemistry, chromatography, biochemistry, microscopy, cell culture and spectroscopy, product development, meat and dairy processing.[18]

Riddet does not provide facility or equipment access directly to food and beverage businesses, but it does provide expertise and human resource.

4.1.16 Springbrook

Springbrook is a privately owned contract manufacturer, based in Blenheim. The company specialises in developing and producing condiments to specific flavour profiles and packaging them into market-ready formats under the client's labels (or Springbrook's own labels).

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[17] Mark Begbie, personal communication, October 2021

[18] https://www.riddet.ac.nz/the-institute/

The company states that its maximum lead time from product idea to initial sample is seven (7) working days, for New Zealand orders.

4.1.17 University of Auckland – Food and Bioproduct Processing

The focus of the university's Food and Bioproduct Processing group is on various aspects of food processing and biotechnology research, specifically the engineering and development of value-added food products and new, cost-effective food processing technologies. Research areas include food processing, microstructure, preservation and transportation, and engineering. The group works with a variety of companies, such as Fonterra and MacDonald's, as well as Plant and Food Research.[19] See Appendix B for more detail.

4.1.18 University of Otago – Department of Food Science / Product Development Research Centre

The Product Development Research Centre (PDRC) offers contract research and consulting services to food companies, with expertise in product development, food chemistry, microbiology, flavour science and sensory science. It works with both large and small companies at all stages of product development.

See Appendix B for a list of facilities and equipment.

4.1.19 University of Waikato – School of Science

The School of Science at the University of Waikato offers a range of different analytical services, survey methods, and scientific equipment hire for commercial use. Its expert scientists are also available for consultancy work to either interpret the existing data or to assist in collecting and interpreting new data.[20]

The facility most likely to be used in the Food and Beverage Sector is the Waikato Mass Spectrometry Facility – see Appendix B for more information.

[19] https://www.auckland.ac.nz/en/engineering/our-research/discover/research-areas-and-facilities/food-and-bioproduct-processing.html

[20] https://sci.waikato.ac.nz/research/analytical-consultancy-services

5. Stakeholder experiences in food and beverage sector

As part of this project, Sapere and Amos Palfreyman as an independent expert interviewed 22 stakeholders on both the accessor and provider side of innovation facilities within the food and beverage sector. The stakeholder experiences with innovation facilities (for both accessors and providers) can largely be grouped into three main categories:

- Demand, relationships, and engagement
- Information availability, sharing, and use
- Administrative processes.

The below section serves as a summary and analysis of key themes and discussion throughout interviews. A detailed appendix with quotes from these discussions is attached in Appendix E.

5.1 Demand, relationships, and engagement

Section summary

- Innovation facilities, where accessible, are enabling good outcomes.
- Human capabilities and expertise are just as important as physical equipment when considering facilities.
- Engagement is usually through informal channels or personal relationships.
- Speed of access acts as a barrier for innovators and has multiple drivers.
- There are not enough scale-up facilities domestically in the food and beverage sector.
- Innovators turn to contract manufacturers, which are imperfect substitutes.
- Private firms are trying to fill gaps in facilities, but this is not widespread.
- It is hard to pin down where demand is greatest, and for what facilities and/or capabilities.

Innovation facilities, where accessible, are enabling and provide relatively good outcomes

Stakeholders on both the accessor and provider side of innovation facilities made it known that the ability to access facilities is generally quite variable; however, where possible, it is enabling and provides relatively good outcomes. Innovation facilities help to de-risk the innovation process by limiting the capital expenditure required to get a product up and running since innovators do not need to invest in their own facilities, which likely allows innovators to get something done faster than otherwise possible and/or undertake projects innovators otherwise would not have considered.

Those accessing innovation facilities exist on a broad spectrum and vary greatly in size and need. Small innovators may need support with everything from conceptual design to commercialisation activity. For larger businesses, the consolidation of world-leading expertise provided by innovation facilities is most appealing because the businesses are large enough (with enough capital) to have some of their own facilities and equipment.

The New Zealand Food Innovation Network (NZFIN) and other publicly funded facilities provide important infrastructure and human expertise to support innovation across the spectrum of the food and beverage industry's needs. Support for innovators to be market-ready, such as export-grade facilities and risk management programmes, makes facilities such as FoodBowl particularly favourable. Some facilities are more comprehensive in their provision of facilities than others and meet specific needs better, so generally facilities point innovators towards better suited facilities if more appropriate.

Human expertise and capabilities are just as important as physical equipment when thinking about facilities

Access is not restricted to just physical facilities; it also includes the human expertise required throughout the innovation process. The required skills and expertise are much broader than just knowing how to operate the equipment available. For example, innovators may access facilities because a resident academic has a novel way of producing a chemical reaction specific to the product type the innovator is working on. Stakeholders stressed that physical facilities are often useless without the expertise to go with them (i.e. hard to uncouple), and therefore there can be issues with access when either physical facilities or human expertise are missing. This can occur due to a mismatch in timing of innovator need and availability of both physical facilities and human capacity.

Engagement usually comes through personal connections or informal channels

The relationship between innovators and facilities is formed through a range of channels. However, it often relies on personal connections and informal channels of involvement, or personal approaches. This obviously assumes that innovators know who to contact in the first place, and how to form personal connections with experts at innovation facilities to utilise informal engagement channels, which is rarely the case.[21] Those with existing knowledge of the food and beverage industry generally know who to contact and go to them directly. More formal channels of engagement do also exist, through the likes of Callaghan, NZFIN, and university research offices which act as intermediaries and to direct potential users to the appropriate facilities and/or expertise specific to their innovation(s).

Speed of access acts as a barrier for innovators and has multiple drivers

Access issues are compounded by the speed at which innovation facilities match innovator needs. Stakeholders noted three general drivers of the lack of speed:

- excess demand for the innovation facilities currently provided
- rigour of process
- conflicting mandates of university and university-associated innovation facilities force a trade-off between innovation and academic research.

There is excess demand for some of the innovation facilities currently provided within the food and beverage sector, which leads to delays in time to access that do not align well with the speed at which innovators want and need to be able to get access. In other words, the innovation cycle is not well aligned with that of the facilities. Innovators need to be able to get access quickly to get an early place

[21] This theme will be explored in more detail in the forthcoming section.

in a novel market and establish a strong footing. If an innovator gets to market too late, other products may have entered, decreasing the likelihood of success. Stakeholders told us that FoodPilot currently has a three-month lead time on any work that innovators want done (i.e. three months until FoodPilot can start), and therefore innovators have been walking away (potentially searching for alternatives, or dropping their idea altogether). Other providers also said it is challenging to fit new innovators in because they are at capacity with current operations. One stakeholder said that part of this is driven by a small supply of food technologists and capable people within the innovation facilities (i.e. they are simply overburdened and cannot find additional staff or budgets to hire them).

Although the rigour of process around innovation is appreciated by innovators (i.e. making processes to export grade standards, meeting certain requirements, etc), it has led to drawn-out processes which can impact the ability of an innovation to be well placed in any given market.

Conflicting mandates of university and university-associated innovation facilities force a trade-off between innovation and academic research. These two activities can have wildly different timelines, which again has the potential to impact on the ability of an innovation to get to market in a timely manner. Firstly, academics often have teaching and separate research (and supervising) responsibilities that take priority over commercial work, meaning innovator projects often take the back seat and are not carried out at a speed that is congruent with the innovators' desires. Secondly, academic reward structures (career progression, renumeration, etc) usually incentivise publications (more is generally better) and therefore innovator projects that require a 'bare-minimum' approach are made into large-scale research papers that will yield many publications. This is again often against the innovators' desires for a quick project to get to market. There are some exceptions: stakeholders said some university or university-associated facilities are getting better at recognising commercial work and industry outcomes when it comes to career advancement and renumeration.

There are not enough scale-up facilities domestically for food and beverage

Stakeholders stressed that there is a distinct lack of scale-up facilities available for innovators to get from small-scale to larger-scale production, both from bench to pilot, and from pilot to commercial. This deficit is more pronounced in certain trending areas, such as plant-based meat analogues and milks. The development of New Zealand's food and beverage industry has been and will continue to be shaped by numerous environmental and institutional factors. Stating that history matters and will continue to matter may seem trivial, but it is useful to set out the processes of technological change present in the industry, as once pursued, strategies and investments cannot be rapidly undone – even when market and social conditions change. The presence of path-dependencies suggests these investments elicit further moves in the same direction (Steward, 2016).

In some cases, publicly funded innovation facilities have the capability to provide scale-up services, but due to excess demand are not accessible. In other cases, the facilities simply do not exist.

If the facilities do exist, then the jump from one step to the next is large and the changes in costs, process, and requirements can be prohibitive, particularly if the innovator is unable to raise capital easily/efficiently. Small-batch commercial runs are often too small to be completed at the likes of FoodBowl, but the lack of alternatives of in-between facilities means that people would have to commit to significantly greater-sized runs and access costs. Effectively, there is a mismatch between innovators' finances and the facilities available.

Further, there is a general reluctance of innovators to invest in facilities that fill this gap because they plan to eventually outgrow them, rendering the facilities obsolete. The innovators' capital expenditure required to set up private facilities would greatly outweigh the use value.

In some cases, innovators have said they are comfortable going overseas to access facilities, innovate, and manufacture. Losing innovators overseas potentially forgoes economic growth and benefits for New Zealand through GDP and clustering benefits (i.e. the benefit of having innovators around each other and synergising).

Unmet demand forces innovators to turn to the private sector, which is generally an imperfect substitute

Excess demand for publicly funded innovation facilities and subsequent time delays force innovators to turn elsewhere, often in desperation to get to market as quickly as possible. Again timing is critical – innovators need to get in and out of facilities as quick as possible. Contract manufacturers may have some of the appropriate equipment for the process but are largely not conducive to innovation and have no mandate or incentives to aid with the innovation process itself or research and development of products.[22] Contract manufacturers are typically rigid in their processes and do not provide the opportunity for refinement or development of products.[23] Effectively, an innovator must be in a near-final state of product and have in-house capability and capacity to make refinements to their innovation to find this service useful.

The required size of runs, the associated costs, and the significant procedural changes when accessing publicly available scale-up facilities are also present within contract manufacturing / private facilities. This is likely since contract manufacturers are dealing in large quantities at the commercialisation stage of the product process. In these private arrangements, innovators are often forced to make upfront payments for consumables used within the process (e.g. bottles, ingredients, lids, etc) to avoid default risk which are typically large due to both scale and timing of payment. These costs and requirements can be prohibitive and therefore make contract manufacturing an unattractive option for some innovators.

In addition to this, contract manufacturers also have issues with capacity since they are typically running commercial-sized operations for existing clients. As a result, large contracts take priority, which can cause innovator projects to take a back seat.

Some private firms are trying to fill the gaps, but this is not widespread

Within some niches of the food and beverage sector there are stakeholders trying to provide private facilities and assistance to other innovators in the absence of publicly funded alternatives. This drive to provide the services and assistance to other innovators typically appears to be for commercial purposes – there are gains to be made for one's own brand when developing new processes and

[22] Contract manufacturers conduct contracted pieces of manufacturing work for clients using the ingredients and formulations provided to them. This is generally performed at relatively large scales and is for commercialisation purposes.

[23] One stakeholder said the contract manufacturer they used was happy to help develop their product and give access to research and development resources. This seems to be an outlier case.

products for other innovators, and benefits from the development of a strong national brand if the products are going to be exported.

This behaviour, however, only exists in small pockets of the industry and is not widespread.

Example: oat milk partnership and private provision of facilities

One example of cooperative research between companies is in the developing oat milk sector. There are currently no public innovation facilities that are suitable for the commercialisation of oat milks, but there are a growing number of oat milk innovators within New Zealand. Stakeholders in the oat milk sector spoke about establishing research to look at taste and flavour preferences for oat milk by different markets. For example, there is evidence that US consumers prefer a different sweetness profile to Asian consumers.

Some private stakeholders are looking to fill the gap in the market for plant-based facilities and oat milk production. Rather than each oat milk company individually funding research and facilities, a consortium could be pulled together to fund it to fill recognised gaps and provide platform knowledge and capabilities for innovators to leverage.

Localisation of demand is hard to pin down; however, it may be concentrated around pilot facilities

The available facilities have different capabilities, meaning they often serve different groups of innovators with different needs. It is possible other public innovation facilities are decent enough substitutes that innovators can move around when facilities are at or over capacity, but in other cases, there are no substitutes that innovators can turn to. Stakeholder experiences did not ultimately make it clear where demand was most heavy, or for what facility use.

The one facility talked about by stakeholders that is at or over capacity and perhaps without many close alternatives is FoodPilot, which has three-month lead times on projects. If facilities truly do redirect innovators to where capacity is, or to where they are best suited to be, then FoodPilot being at or over capacity suggests other pilot-scale facilities may not be good substitutes.

Further research and insights into demand for different public innovation facilities are necessary to be able to make robust conclusions.

5.2 Information availability, sharing, and use

Section summary

- Innovators are naïve about the innovation process.
- Generally poor awareness about public facilities, capabilities, and alternatives within New Zealand.
- Lack of marketing of the capabilities of facilities might drive poor awareness.
- Issues around succession and retaining knowledge and expertise at public facilities.
- Competition in foundational research space might be stifling innovation.

Naivety amongst innovators about the innovation process

Stakeholders consistently discussed the naivety amongst innovators about all things to do with the innovation process, including the:

- importance of research and development in the innovation process, and the subsequent costs
- significance of taking a product from kitchen to commercial-scale production
- general cost of access to facilities
- the amount of time and effort that must go into different steps of the innovation process.

The knowledge of how to go about the innovation process and all the different pieces of the puzzle is generally missing within the cohort of innovators, particularly those who are new to innovation and come from non-technical backgrounds outside of food science. Those with some sort of experience within the industry previously would generally have a greater understanding of the innovation process and the requirements. One stakeholder suggested a focus on entrepreneurship globally has driven people who typically had nothing to do with innovation to become innovators, often with little to no experience or understanding of the innovation process and in turn a naïve view of what can be done.

Often innovators complain about the cost of research and development and say it is prohibitive. One stakeholder suggested part of this is because of a deeper lack of understanding of the importance of research and development and the role of research in developing innovative ideas that eventually lead to greater returns and more successful products.

One stakeholder said innovators often have a misconception about the ease of scaling-up from kitchen scale to commercial facilities and generally think of it as a minor undertaking. In the stakeholder's experience, however, the scale-up process was significant and contributed to a third of their cost throughout their entire innovation process. The change from kitchen to commercial scale production introduces a range of new issues and process requirements that are often not thought about by innovators, such as temperature controls, storage, equipment configurations, and so forth. As a result, innovators may be underestimating the resources required to be able to get their products to a stage of commercialisation.

Providers stated that innovators are often put off by the price of access to facilities, perceiving it as high and prohibitive. These perceptions do not always consider the inputs that drive the costs, or the value that is derived from the costs that are incurred. For example, one of the key costs at FoodPilot is the compliance costs associated with being able to export directly from the facility. These are the same standards for any food production factory, and therefore require rigorous processes and extra steps to be taken to ensure eligibility for export. As a result, costs at FoodPilot may be relatively higher than elsewhere, but at the same time the value of being able to export directly from FoodPilot is not being considered or recognised by the innovators.

The naivety about costs is particularly variable across different types of innovators. Providers said that often the smallest innovators were the easiest to deal with because they are generally more willing to pay and trust the expertise, given they are shown the value or outcome of their investment.

Naivety about the time and effort required for the innovation process may also lead innovators to feel the process at innovation facilities is prohibitive to successful innovation. One provider mentioned that innovators often have issues with timelines but do not consider how changes to the scope of their research and innovation impact timelines. Clearly, as the scope changes, the potential for the timeline to change increases as well since there may be new considerations, research, and processes to be undertaken. Ultimately, this comes down to the innovators' expectation that science and research is an "off-the-shelf" product that is rigid in the way it is used and designed. In actuality, science and research for an innovation is typically bespoke.

Poor awareness of facilities, capabilities, and alternatives in the country

It is overwhelming clear from both accessors and providers of innovation facilities that awareness of facilities' existence and their respective capabilities, expertise, and alternatives is poor. Some of the naivety mentioned above may lead to innovators' poor awareness; for innovators it is hard to know where to look if you do not know what you are looking for. Innovators are generally not sure where to go or who to talk to when wanting to collaborate and start the innovation journey. For innovators that have been able to access facilities, knowledge of the help available to them was uncovered by chance and through being in the right place at the right time.

We heard consistently from stakeholders that there is no easy way to locate the appropriate facilities and expertise, except if an innovator had experience within the food and beverage sector, such as a studying a food technology degree that provided connections via academia, previous employment with a company that had dealt with an innovation facility, or employment with an innovation facility directly.

A lack of marketing of capabilities might drive the poor awareness of facilities

This poor awareness is likely driven by a lack of facility-side marketing and signposting of the services provided and facilities available for innovators to access. Accessors said that firstly, facilities are not good at communicating the capabilities they have to innovators in layman's terms. Although some innovators have food technology backgrounds, a large number do not, and therefore they are unable to interpret easily what each facility does and how it differs from others. As a result, this proves to be a barrier to access for some innovators, since there is no clear understanding of what is available to them.

Providers also recognised that this is the case, and that a lot of innovators were likely unaware of their facilities and the capabilities specific to them because the facilities do not make it obvious to outsiders.

Internal awareness is likely a bit better, but perhaps not perfect

Within the network of facilities, awareness is likely better than for outsiders. When innovators can successfully find a way in, facilities are helpful in pointing out where capabilities are and what facilities are most appropriate given specific contexts and projects.

However, stakeholders suggested that in some areas, knowledge is siloed and there is a disconnect where knowledge does not flow freely or easily from academia and innovation facilities to industry, and vice versa. There are clear benefits from knowledge sharing (decrease in time spent searching, etc); however, these benefits are forgone when knowledge is siloed as those at facilities likely have to duplicate work to find things out, or conduct similar/identical research.

Potential issues surrounding succession and the ability to keep knowledge and information within facilities

Stakeholders have expressed concern about succession and the ability to keep knowledge and information within facilities. Within some facilities, knowledge and expertise lies within small groups of people and is not well shared outside of that. Once those people retire (likely in the short term), there will be a gap in capability. It was also mentioned that New Zealand typically has a high reliance on overseas markets to fill gaps in capability at innovation facilities.

Part of the concern is driven by the inability to hire people with experience in the industry to work at the innovation facilities. The two main reasons given for this are the constrained budgets of the facilities, and the significantly smaller salaries at facilities compared to within industry. Innovation facilities typically operate on tight budgets dictated by through government funding and generally operate close to a cost-recovery structure that leaves little room for additional hiring. When there is extra funding available to hire, the salaries able to be offered pale in comparison to what someone may be able to receive within industry.

Should there be no succession or hiring of people into the innovation facilities, the impacts will be significant and will exacerbate current excess demand, making the facilities less accessible.

Competition within the foundational research space might be stunting innovation

There is potentially competition within foundational research in the food and beverage sector which might be stunting innovation and preventing innovative New Zealand firms from getting to international markets in a timely manner. One stakeholder suggested this may come down to New Zealand lacking a unified strategy or directive of what products and innovations should be focused on and supported as opposed to a scattered approach where there is a broad spectrum of innovators operating in different corners of the food and beverage industry, competing for funding and activity. Currently, innovators are incentivised to compete for foundational research with limited resource, which results in relatively long timelines of innovation development. Again, this opposes the core requirement of innovation of having fast access to facilities to be able to get to market as quickly as possible.

If there was collaboration, pooling of resources, and/or government support in building foundational research and open-source foundational IP, innovation timelines may become shorter, and the capital required by innovators to get their products up and running may be significantly less.

Stakeholders mentioned Canada, the Netherlands, and Brazil as important examples where foundational research is typically not competitive and is rather funded and supported by the government to be a collaborative activity that generates open-source foundational IP which can then be used in many ways. This ultimately increases the speed of innovation development and decreases the amount of capital an innovator requires to be able to get their product up and running.

5.3 Administrative processes

Section summary

- Cost of access may be a barrier for some innovators.
- IP is a messy and complex issue encountered by almost everyone.
- There may be mismatches in the expectations of funders and the processes of facilities.
- Funding, where available, enables access to innovation facilities that otherwise would not be possible, but is generally limited.

Cost of access is considered a barrier for some; however, naivety should be considered

Stakeholders trying to access public innovation facilities often raised cost as a significant barrier to entry. In one case, a stakeholder went to a private contract manufacturer instead of a publicly funded innovation facility because it was cheaper, even with a small-sized run.[24] University and university-associated facilities also incur overhead costs, which are considered significant and caused one innovator to consider going elsewhere.

One potential driver of costs is equipment utilisation and the ownership of low utilisation but high specialisation equipment at some innovation facilities. With high specialisation (or hyper-specific) equipment, there are often low utilisation rates. Low utilisation rates typically mean higher use costs. Lower utilisation rates may also mean that recovery of capital expenditure on these pieces of equipment spills over onto more general equipment, driving up the use costs for other higher utilisation pieces of equipment (i.e. increasing the use and access costs more generally, and overall).

If the costs are too high, small innovators will be priced out of access. If the costs are too low, then innovators will occupy innovation facilities for too long. There is no simple answer to this issue. There exists a trade-off between providing a breadth of equipment to accessors and keeping utilisation sufficiently high that accessors can get access to the equipment as well as keeping costs relatively low.

As per previous discussion, innovator naivety may also drive some of these perceptions about high costs (i.e. not realising all different cost contributions and derived values). Therefore, further analysis of costing of innovation facilities compared to alternatives is likely necessary to establish any clear conclusions.

[24] This case, however, is likely an exception. The stakeholder had considerable experience in the food and beverage sector and knew where to look for alternatives. Others without the experience may have simply seen this as prohibitive without being able to identify cheaper options.

It is worth noting that equipment that may start out as highly specialised with low utilisation can shift to become more highly utilised as the industry adjusts and takes on new trends (i.e. the process becomes more mainstream). As a result, being at the forefront of innovation and being able to respond to shifting consumer demands requires having some highly specialised equipment. An example of this is the extruder at the FoodBowl which went unused for many years (i.e. high specialisation, low utilisation piece of equipment). With the recent boom in plant-based meat analogue demand and production, the extruder is increasingly in demand. Without access to the extruder at FoodBowl, some meat analogue innovations would have never been successful.

IP is a messy and complex issue

Accessors of publicly funded innovation facilities had concerns about the way IP is handled, which can ultimately stifle the innovation process and ruin the potential for collaboration. Some accessors raised concerns over the way IP was treated, particularly within NZFIN. They said that for certain product types within the food and beverage sector there were certain facilities that would provide more favourable outcomes, such as shorter timeframes and lower cost.

The publicly funded providers of innovation facilities (like NZFIN) need to be able to work with multiple clients and on very similar products; therefore, the clients drive the products and not the providers. Otherwise, it would be a first-in-first-served situation and innovators would be able to close out other innovators by monopolising certain innovations (i.e. if one did oat milk, another would not be able to if the process was driven by the facilities).

In some examples, innovators are being led to particular facilities within NZFIN because that is where the expertise has been developed, which innovators suggest shows previous projects and their respective IP developments have informed the processes and facilities currently used. Effectively, innovators are concerned that any IP they generate in these facilities will then sit with the experts and be used in future projects, giving future innovators a "head start". This, however, is always going to be challenging to manage as facilities cannot "unknow" what was developed but can try to compartmentalise knowledge and data and block innovators from encroaching others' IP where possible.

IP issues for innovators may be even more significant when considering contract manufacturers. Since they do not have the same mandate as publicly funded innovation facilities, there is no incentive to cooperate or protect the innovators' IP. Anything developed in-house during the contract manufacturing process is easily gleaned by the contract manufacturer. Stakeholders mentioned that because of this, they would prefer to work with publicly funded innovation facilities.

On the other side, there is variability in the way IP is managed across different facilities. Some facilities give all developed IP rights to the innovator, while other facilities take some of the rights and therefore royalties from future IP use. This seems to require a balancing act to make sure that innovators are still willing to access the facilities, but the facilities can make some return on their investment of labour and capital in the innovation process.

IP management becomes particularly complex when students are involved at university or university-associated facilities, since students typically need to be able to publish their findings and do not fall under the same IP rules as academics. Students are often cheaper to employ for the purpose of research, but the hidden cost of doing so (or forgone benefit) is the forfeit of some IP control.

Issues with IP ultimately sour the relationship between innovators and facilities and prove to be a barrier to access for innovators when there are concerns about the way it will be handled.

Potential mismatch between the process of a facility and the funder of project

One stakeholder raised the point that the process expected by a funder of a project can vary considerably from the processes normally employed for innovation by a facility. The key differences typically come down to deliverables and objectives. For universities specifically, an academic/researcher is typically self-guided and has less deliverables than a normal commercial project. The requirements of funders of projects that are commercial mean that there can be a mismatch of process and additional resource constraints/stresses throughout the innovation journey.

It is not ultimately clear if this is a widespread issue and would need to be explored further to understand the resource constraints/stresses this imposes, and the significance.

Funding, where available, enables access to innovation facilities but overall is restricted

Several stakeholders commented that they were able to access innovation facilities because of funding available from the New Zealand government through various channels. The main channel mentioned was Callaghan, which offered a variety of grants and loans for research and development and innovation. New Zealand Trade and Enterprise was also mentioned as it had funded a feasibility study for an innovator.

In general, however, funding is restricted, particularly from Callaghan, which has a relatively narrow definition of R&D. Even when innovators can access funding from Callaghan, the innovator must still contribute a significant portion toward the costs (around 60 per cent at least), which is a sizeable amount for small innovators. Effectively the funding that is available acts as a "nudge" to get innovators over the line. The Regional Business Partners that administer the Callaghan Innovation grants are also very variable in the degree of help and knowledge they provide when engaging local partners. Also, project grants (funding) from Callaghan Innovation for the 2021 financial year were paused in October due to the full fund being spent,[25] meaning innovators wanting to apply for R&D funding must now join a waitlist to apply for the next round of R&D funding in 2022 unless innovators have prior arrangements with Callaghan Innovation. This delay in access to funding again goes against the strict timeframes innovators often have to get to market.

[25] https://www.callaghaninnovation.govt.nz/rd-funding/2021_ProjectGrants

6. Expectations of future demand for facilities

Section summary

- Heightened demand for plant-based foods and beverages and therefore likely facilities too.
- Excess demand will remain in absence of change, and could potentially increase over time.
- Government policy changes and private provision of facilities have the ability to decrease demand for public facilities.
- Covid-19 has caused delays and disruptions but also been linked to an influx of returning Kiwis, with anecdotal evidence of this arrival increasing demand on innovation facilities.

Trends in food and beverage product types and consumer preferences largely dictate what will be in demand and therefore what facilities are required. Forecasting future demand for food and beverage innovation facilities is inherently difficult for a range of different reasons:

- Although there may be expectations about short- to medium-term trends within product types and consumer preferences, long-term forecasts are inaccurate and effectively impossible.
- The ability for consumer preferences to change overnight (particularly in a hyper-connected, internet-enabled world) complicates any expectations of short-, medium- and long-term trends and increases the uncertainty around expectations.
- Utilisation data has not been provided, which limits the quantitative analysis able to be conducted.[26]

Despite this, there are some comments that can be made based off the stocktake of facilities, literature, and stakeholder experiences about general national and global trends within the food and beverage sector that will likely have impacts on future demand for innovation facilities.

Heightened demand for plant-based foods and beverages, and therefore likely facilities

Global trends of sustainability and heightened social consciousness in the age of climate change are informing diets in developed, wealthy countries, and are encouraging consumers to substitute resource-intensive foods and beverages such as meat and dairy milk for plant-based alternatives (Beverland, 2014; Hemler & Hu, 2019; Sabaté & Soret, 2014). From stakeholder experiences, it seems that a key focus of innovation currently in New Zealand is on meat analogues and plant-based milks such as oat milk.

There are currently not many facilities that have the capacity or capability to produce these domestically, since facilities are typically set up for meat and dairy because of historic production focus. As a result, there is excess demand for facilities that can assist with plant-based food and

[26] Even with utilisation data, estimates of future demand would likely be highly imprecise and subject to a lot of variability because of the points mentioned prior.

beverage innovations. It seems reasonable to assume that this trend will continue to be driven by climate change and, therefore, there may be increased demand in future for facilities that are capable of plant-based food and beverage innovation and production.

If nothing changes, excess demand will remain, and could potentially increase

It is clear there is current excess demand for facilities in the food and beverage sector, wider than just those which can assist with plant-based products. The demand seems most severe in scale-up facilities because there simply are little to none available, and for capabilities that FoodPilot provides. Part of this is likely due to the succession problem mentioned earlier – private industry continues to be a more attractive place to work for food technologists due to higher salaries. Without any change in incentives (higher salaries, etc) or strengthening of pathways for careers in innovation facilities, there will likely continue to be a lack of capability and expertise within facilities.

A lack of capability and expertise within facilities effectively limits the amount of innovation work that can be conducted at the facility, perpetuating excess demand and potentially leading to poorer outcomes.[27]

Some of the excess demand recognised is localised in scale-up facilities. Stakeholders identified a distinct lack of scale-up facilities which are crucial to be able to get an innovation from bench to pilot scale, and from pilot to commercial scale. Stakeholders mentioned commitments (both public and private) to fill these gaps; however, it is not clear how certain these are or what timeframe they are expected to be developed in. If these fall through, the gaps and excess demand for scale-up facilities will persist.

Covid-19 has caused delays and disruptions but has also been linked to an influx of returning Kiwis, many of whom are entrepreneurial. There is anecdotal evidence of increasing demand from this influx for food and beverage innovation facilities.

Demand for public innovation facilities could decrease because of government policies as well as private provision of facilities

Current government policies and interventions are designed to promote innovation and incentivise innovators to access public facilities. This is because innovators typically lack the capital or are reluctant to invest in their own facilities, particularly when risk of failure is high. Without public provision of innovation facilities, the level of innovation nationally would likely be lower than it is currently, and New Zealand would struggle to keep up globally as an advanced economy.

Demand for public innovation facilities is a function of the policies and regulation set by the New Zealand Government. A change to policies and regulation that makes innovation harder (i.e. lowers the incentives to innovate) will likely reduce the demand for public innovation facilities. Some

[27] If there is not a sufficient level (or quality) of expertise innovators may not access the facility (i.e. because the facility does not suit the innovators needs) and may go elsewhere in New Zealand or overseas. Where the innovator still does access the facility, the innovation process may take longer (effectively putting capacity constraints on the facility and closing out other innovators) or provide relatively poorer outcomes with a lower level of quality of innovation.

examples of changes to policies and regulation that would likely reduce the demand for public innovation facilities are:

- A decrease in the amount of grant funding allocated in the national budget to R&D activity. A lower level of grant funding would likely result in a lower number of innovators being able to conduct R&D, and therefore a decrease in demand for public innovation facilities (i.e. increase barriers to innovation).
- Removal, or lowering of R&D tax incentives (currently at 15 per cent rebate). This would effectively make R&D activity more expensive and likely reduce the demand for public innovation facilities.
- Removal of some public innovation facilities, or the funding that enables them to operate. This will decrease the capacity of existing public innovation facilities and likely force some innovators out of the market (which will lower the amount of demand by lowering the size of aggregate demand). Those forced out of the market for public innovation facilities may go to private facilities or overseas.

Demand for public innovation facilities could also decrease if private innovation facilities are constructed and serve as a closer substitute than contract manufacturers do currently. This may be the case particularly in areas where public innovation facilities currently do not exist, such as scale-up facilities for plant milk products. Rather than trying to make imperfect public innovation facilities work, innovators may move to private facilities, thus decreasing demand for public facilities.

Changing regulations and global commitments are driving major shifts towards more sustainable food packaging

Sustainable food packaging is an ongoing issue that was placed on the backburner during Covid-19 but remains a serious issue for the NZ food industry. Customer expectation and government commitments globally will require NZ to evolve to meet new regulations and expectations over the coming years. Current sustainable packaging options in the food industry often require a trade-off in price, shelf life and/or capacity. A potential consortia of large NZ food companies who could approach the problem in a pre-competitive way has been mooted with industry and has gained interest.

The recently created Plastics Innovation Fund may provide another pathway for food and beverage innovators to access funding. Other changes such as the phasing out of hard-to-recycle plastics might force some food and beverage companies to change packaging.

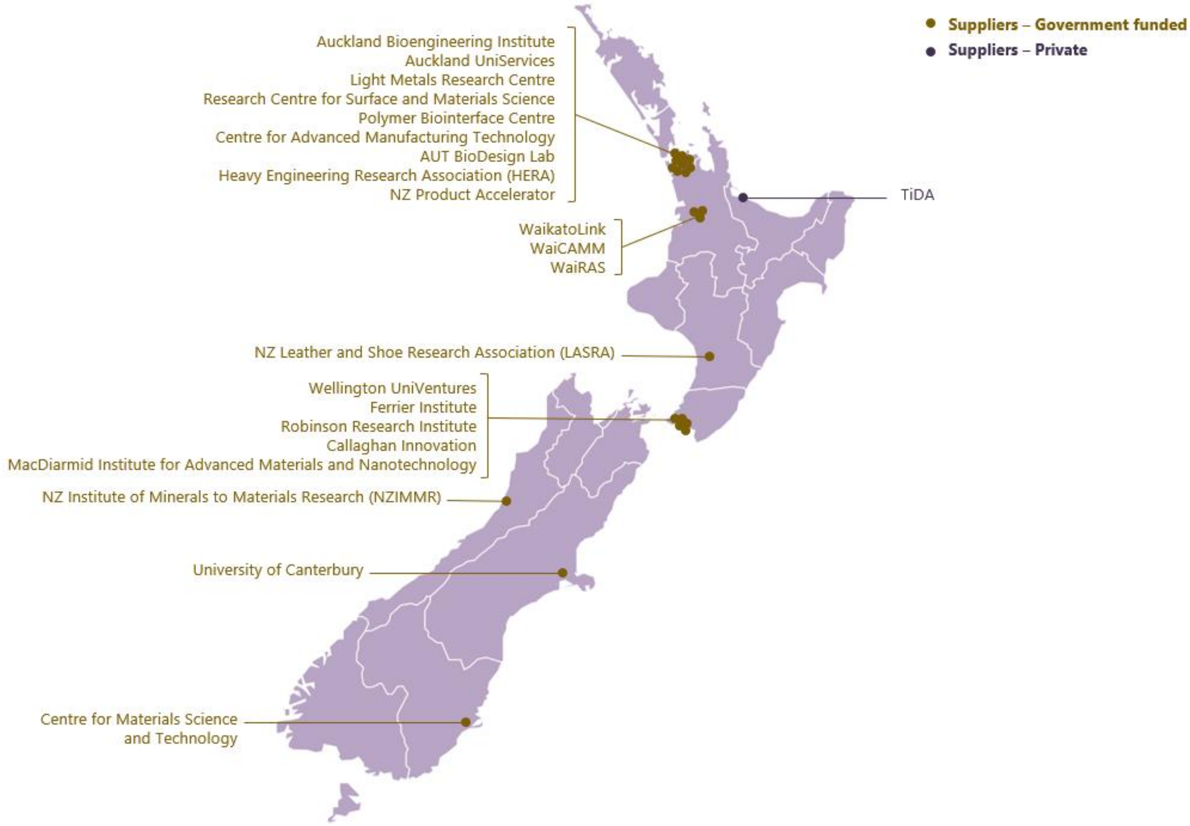
Packaging has been an initial focus of many of the efforts to rethink plastics because of its sheer volume, pervasive nature, short timeframe of use, and frequent presence in marine litter clean-ups. Over half of the raw resin imported into Aotearoa New Zealand is manufactured into packaging.[28]

[28] https://www.pmcsa.ac.nz/topics/rethinking-plastics/changing-our-relationship-with-plastics/

7. Advanced manufacturing sector

The government supports access to advanced manufacturing innovation facilities directly and indirectly through a range of channels. These include funding basic and applied research through the likes of Callaghan Innovation funding, the MBIE Endeavour Fund,[29] and indirectly through the Royal Society of New Zealand Catalyst Fund, and incentivising firm's business R&D through grants and tax credits (e.g. 15 per cent tax credit on R&D spend).

Figure 4: Map of advanced manufacturing providers



7.1.1 Auckland Bioengineering Institute (ABI)

The Auckland Bioengineering Institute (ABI), based at the University of Auckland, applies engineering sciences and technical innovation to medicine and human physiology. ABI collaborates with national and international universities and research institutions. It works with Auckland UniServices Limited on intellectual property, licensing agreements and consultancy services, and with consultancy The Icehouse for new business incubation activities.[30]

[29] This totals approximately $57 million annually across all areas of science. It is made up of $18 million for 'Smart Ideas' innovations, and $39 million for larger Research Programmes.

[30] https://www.auckland.ac.nz/en/abi/business-community/collaboration-activities/collaborations-associations.html

Research areas include biomimetics and augmented human technologies, and computational and experimental physiology.

See Appendix C for the full list of research areas, equipment and pricing.

7.1.2 Auckland UniServices

Auckland UniServices' 'Return on Science' programme works to "increase commercial outcomes from publicly funded research". It provides advice and expertise to companies and start-ups and can connect them to funding sources. Its expertise is in business planning, market testing, intellectual property development and financing. Between 2016-2020, Auckland UniServices was involved in starting over 40 companies and licensing 445 patents.[31]

7.1.3 AUT Biodesign Lab

The AUT Biodesign Lab is a team of researchers across several disciplines, focused on human health. The lab has worked with many external companies and start-ups to provide design innovation, help in the concept stage, and business advice, networking, and scientific expertise at little or no cost; however, it is not apparent from the lab's website that it provides these services, despite inviting collaboration. The lab provides limited access to facilities and equipment.

See Appendix C for a full list of research areas and partner organisations.

7.1.4 Callaghan Innovation

Callaghan Innovation offers a range of services and programmes to the advanced manufacturing sector, providing facilities, expertise and connections to companies. This includes:

- Product or process design
- Proof of concept prototyping
- Process assessment
- Post-treatment
- Performance testing
- Product specification.

The Gracefield Innovation Quarter's (GIQ) facilities in Lower Hutt are currently being developed and upgraded.[32] GIQ's facilities include laboratories, workshops and pilot labs, a machine shop, rapid prototyping facilities, glassblowing, a collaborative robot, polymer and metal 3D printing, materials analysis and testing laboratories, a supercritical fluid extraction plant, and measurement facilities.[33]

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[31] https://www.uniservices.co.nz/about

[32] https://www.callaghaninnovation.govt.nz/news-and-events/updates-redevelopment-gracefield-innovation-quarter-giq

[33] https://www.callaghaninnovation.govt.nz/technology-and-product-development/gracefield-innovation-quarter

Callaghan has approximately 200 scientists and engineers to deploy into businesses or R&D projects for businesses. Its main locations are in Lower Hutt (headquarters) and Wellington, Auckland and Christchurch.

7.1.5 Centre for Advanced Composite Materials (CACM)

The Centre for Advanced Composite Materials is based at the University of Auckland in Newmarket. Its core focus is research, on topics such as liquid composite moulding, formability and rollforming, biocomposites manufacturing, and machinability of composite products.[34]

CACM's facility includes a range of laboratories and workshops. Full details of facilities and equipment are found in Appendix C.

7.1.6 Centre for Materials Science and Technology

The Centre for Materials Science and Technology (now the Clothing and Textile Centre) is located at the University of Otago in Dunedin. It focuses on fibres, textiles and materials in engineered solutions. It provides consultancy services and expertise to businesses and undertakes collaborative research. Research themes include:

- Characterisation of selected fibres, fabrics, leather and clothing, and the effect of these on properties and performance
- Development of medical and sensing textiles which function effectively in contact with the human body and during repeated use
- Effects of clothing and textiles on human performance; preventing and/or minimising severity of injury
- Engineering analysis including finite element analysis and computational fluid dynamics.

See Appendix C for facilities and equipment.

7.1.7 Ferrier Institute

The Ferrier Institute, based at Victoria University of Wellington, is available to businesses to undertake contract research in renewable polymer formulation for products and applications. Ferrier also provides advice and expertise.

See Appendix C for facilities.

7.1.8 Heavy Engineering Research Association (HERA)

HERA is an industry-owned, membership-based, non-profit research and industry development organisation for metal-based industries. HERA is set up under a statute and funded by a compulsory levy through the Heavy Engineering Research Levy Act 1978, obtained through the sale of steel and welding consumables throughout New Zealand. While the emphasis of its activities is on heavy

[34] https://www.cacm.auckland.ac.nz/en/cacm/cacm-our-research/cacm-advanced-manufacturing.html

engineering, HERA also services wider metals industry interests such as in light-gauge steel, stainless steels and light alloys. It is based in Auckland.

HERA's consultancy services include design engineering, finite element analysis, structural fire engineering and seismic design.

HERA's Fab4.0Lab focuses on the technologies that will facilitate the implementation of integrated 4.0 data collection and analysis, including:[35]

- 3D scanning + augmented reality
- Data collection
- Digital twin demonstration
- Connectivity
- Productivity analysis
- Digital quality monitoring data
- Advanced 4.0 training.

Pūtātara is HERA's in-house media room facility.

7.1.9 MacDiarmid Institute

The MacDiarmid Institute for Advanced Materials and Nanotechnology is a New Zealand Centre of Research Excellence specialising in materials science and nanotechnology. It is hosted by Victoria University of Wellington, and it is a collaboration between five universities and two Crown Research Institutes:

- Victoria University of Wellington
- Massey University
- University of Auckland
- University of Canterbury
- University of Otago
- Callaghan Innovation
- GNS Science.

The Institute does not currently collect information on capacity, usage, products supported, and accessibility by non-owners. Much of the equipment is utilised on an informal and decentralised basis, with complex and varying levels of access and support for each piece of equipment across the network.

[35] https://www.pressreader.com/new-zealand/demm-engineering-and-manufacturing/20210701/281938840908414

7.1.10 New Zealand Institute of Minerals to Materials Research (NZIMMR)

NZIMMR is based in Greymouth on the West Coast. Its purpose is "to research new economic opportunities from adding value to New Zealand's mineral resources, including low-emissions technologies".[36] It has both a minerals processing laboratory and a minerals-to-materials laboratory. NZIMMR partners with the mining industry, researchers, materials manufacturers and West Coast iwi. It is unclear what services NZIMMR can provide to businesses in advanced manufacturing.

7.1.11 New Zealand Leather and Shoe Research Association (LASRA)

LASRA is a research and technology provider to the hide, skin, leather and footwear manufacturing sectors in New Zealand and Australia. It provides research and technical support to exporters. LASRA is the major provider of safety footwear testing services in Australasia. Much of its research is co-funded by the government. It undertakes analytical testing and efficacy projects for manufacturing companies and provides recommendations for further development.[37]

Capabilities:

- Dedicated facilities for trial leather production and product testing
- Physical and chemical analytical testing of footwear, textiles, leather, partially processed leather, leather process chemicals, collagen, and industrial waste
- Chemical analyses for activity, purity or contamination on all type of reagents used in the leather processing industry.

7.1.12 New Zealand Product Accelerator

NZPA assists companies with its expertise, from scoping to research team identification, contracting, deployment, and delivery of projects.[38]

Capabilities include practical business skills and technology development and application. Its technological capability is centred in materials and surfaces, manufacturing systems, bioprocessing and recycling, design innovation, energy and emissions, and sensing, monitoring and automation.[39]

NZPA does not appear to own facilities or equipment, but provides access to a network of its research partners, including:

- Callaghan Innovation
- The University of Auckland
- Auckland University of Technology
- The University of Waikato

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[36] https://nzimmr.co.nz/about-us
[37] https://www.lasra.co.nz/research/
[38] https://www.nzproductaccelerator.co.nz/what-we-do-2/
[39] https://www.nzproductaccelerator.co.nz/

- Massey University
- Victoria University of Wellington
- University of Canterbury
- University of Otago
- The MacDiarmid Institute
- GNS Science.

7.1.13 Polymer Biointerface Centre

The Polymer Biointerface Centre, based at the University of Auckland, is focused on research in bioelectronics, sensors, membranes and packaging, and tissues interfaces.[40] It is unclear whether it offers collaboration or contract services to manufacturing companies.

7.1.14 Research Centre for Surface and Materials Science (RCMS)

The RCMS at the University of Auckland provides expertise to industry, including training, problem analysis, and written reports. It specialises in materials characterisation, i.e. composition and structure of materials. RCMS is made up of cross-disciplinary researchers from within the university and collaborates with external universities and CRIs.[41]

See Appendix C for a summary of the RCMS's equipment.

7.1.15 University of Canterbury

The University of Canterbury's College of Engineering provides students to consult on a wide range of university-supervised industry projects, with the innovative company acting as project sponsor. Outcomes may include proof of concept or prototypes, analysis, feasibility studies, or test data.

A wide range of the College's equipment and facilities is listed in Appendix C.

7.1.16 Robinson Research Institute

The Robinson Research Institute, based at the Gracefield Research Centre in Lower Hutt, is made up of 25 scientists and engineers who are experts in high-temperature superconductivity (HTS). The Institute's main research areas include HTS Roebel cable, magnet systems, superconducting power systems, robotics, magnetic sensors, and novel electronic systems (superconductors, spintronics and hybrid materials). Its services to companies may involve access to the facility (i.e. to investigate and prototype new compounds), training and consultation, and research and expertise.

Equipment at the facility is listed in Appendix C.

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[40] https://www.auckland.ac.nz/en/science/our-research/research-institutes-and-centres/polymer-biointerface-centre/our-research.html

[41] https://www.auckland.ac.nz/en/engineering/our-research/discover/research-areas-and-facilities/rcsms.html

7.1.17 Titanium Industry Development Association (TiDA)

TiDA Limited is based at Toi Ohomai Institute in Tauranga. It was set up with the support of several public and private sector organisations to "help co-ordinate titanium metallurgy and additive manufacturing activities for the long-term benefit of the New Zealand industry".[42] TiDA offers research and development, thermal processing and microscopy, additive manufacturing processes, materials testing, and CAD software and analysis.

TiDA's partners include the University of Waikato, WNT Ventures, Callaghan Innovation, GNS Science, Toi Ohomai Institute of Technology, Page Macrae Engineering and RAM 3D.

See Appendix C for equipment and facilities.

7.1.18 University of Waikato – School of Engineering

The School of Engineering at the University of Waikato has two research centres that are likely to be used by innovative firms in the Advanced Manufacturing sector:

- Waikato Centre for Advanced Materials and Manufacturing (WaiCAMM)[43]
- Waikato Robotics, Automation and Sensing (WaiRAS)[44]

Waikato Centre for Advanced Materials and Manufacturing (WaiCAMM)

WaiCAMM is an interdisciplinary research centre that encompasses a broad range of world-leading expertise in natural fibre and high performance composites, powder metallurgy and specialty alloys, functional materials, characterisation, through life inspections and failure prediction. The centre is open to establishing partnerships with industry and research organisations to strengthen the materials research capability in New Zealand.

Waikato Robotics, Automation and Sensing (WaiRAS)

WaiRAS is a group of researchers, with skills spanning artificial Intelligence, machine learning, computer vision, time-of-flight sensing, non-destructive testing, control and bespoke hardware development. Its mission is to produce both world-leading academic research and solutions for New Zealand industry, including horticulture, agriculture, aquaculture, dairy, forestry and construction.

Capabilities:

- Agri Robotics
- Applied Machine Learning
- Sensing
- Robotics

[42] https://tida.co.nz/about/
[43] https://eng.waikato.ac.nz/research/WaiCAMM
[44] https://eng.waikato.ac.nz/research/WaiRAS

7.1.19 Waikatolink

Waikatolink is the commercialisation arm of the University of Waikato and works with researchers and industry. Product developers go through a pipeline process to develop and commercialise intellectual property, from screening to assessment, commercial development, negotiations and pre-launch. Waikatolink can help to access investment funding, plan commercialisation strategies and provide access to networks of experts and mentors.[45]

7.1.20 Wellington UniVentures

Wellington UniVentures is part of Victoria University of Wellington and provides commercialisation services for innovators. It provides expertise in product development and access to networks and investment sources.

Partners include Victoria University of Wellington, KiwiNet, Biolink, NZ Trade and Enterprise, Ferrier Research Institute, MacDiarmid Institute, Robinson Research Institute, Albert Einstein College of Medicine, Ministry of Foreign Affairs and Trade, Shanghai Institute of Materia Medica, NZ G2G Know-How, GlycoFineChem, and Humankind.[46]

[45] https://waikatolink.co.nz/researchers/
[46] http://viclink-uat.sites.silverstripe.com/about-us/our-partners-2/

8. Advanced manufacturing stakeholder experiences

Sapere conducted 28 interviews during the stakeholder consultation period.[47] Of useful comparison for this section is the *Powering Innovation: Improving access to and uptake of R&D in the high value manufacturing and services sector* report from 2011 commissioned by the Ministry of Science and Innovation (MSI) that sought to capture insight into R&D activity (MBIE, 2011).[48]

Part of the report captured stakeholder perceptions of barriers to access and uptake of R&D in the high-value manufacturing and related services sector, allowing us to see if any of the barriers identified in the 2011 report are still present currently, or relatable to, access to innovation facilities, and if there is any indication of changing trends/behaviours between 2011 and current that may impact demand for access to innovation facilities.

8.1 Demand, relationships, and engagement

Section summary

- Access to innovation facilities includes expertise as well – it is difficult to uncouple equipment and knowledge/technical skills.
- Ability to access facilities is variable, as are the capabilities provided by different facilities.
- There may be some duplication of facilities across the country (or even within institutions) that could have implications on the cost of access.
- Scalability of innovation appears to be a problem in advanced materials and manufacturing.
- Speed of access and process is generally slow at innovation facilities.
- Some providers are conflicted when providing services to innovators.
- Large focus on personal networks to form innovation partnerships/relationships.

Facilities are not limited to just physical equipment – they include expertise as well

It is often hard to uncouple physical facilities and equipment and expertise since they are usually co-dependent. Some innovators require both physical facilities and equipment as well as expertise to make their innovation successful. Others may only require one or the other, or both but with minimal inputs on one side (e.g. 90 per cent physical equipment, 10 per cent expertise).

Stakeholders told us that managing demand for facilities and expertise is difficult and that demand can be patchy with huge variability. Demand management requires good coordination between

[47] This refers to the number of stakeholder groups interviewed. In many interviews, more than one representative was present.

[48] Appendix 2 of the report (p76-86) discusses the barriers to access and uptake of R&D in the high value manufacturing and related services sector.

accessors and the facilities themselves to ensure that utilisation of equipment and expertise remains stable and innovators can get access when they need it.

Ability to access innovation facilities is variable, as are the capabilities the facilities provide

Stakeholders made it clear there is variability in the amount of access and the ways to access innovation facilities within the advanced manufacturing sector. Additionally, the capabilities the facilities provide varies greatly. A lot of innovators in the advanced manufacturing space are operating in hyper-specific niche areas which public innovation facilities are not always able to easily provide equipment and expertise for. Some stakeholders suggested they have internalised R&D processes because of the lack of capability and capacity in the public innovation facilities for the projects that they want to complete. As a result of hyper-specific niche activity, innovators do not always have access to alternative facilities (public or private) in New Zealand. One area mentioned was textiles, where innovators routinely must go overseas for testing capability and capacity in certain applications.

When accessible, however, stakeholders said the facilities generally provide good equipment and expertise that would otherwise be unobtainable or unusable for innovative firms. As one might expect, access seems to be better for more general innovations within the advanced manufacturing sector that make use of common equipment and expertise, such as 3D printers and electron microscopes (where there are many alternatives available).

Some stakeholders mentioned there can be crossover with other sectors and demand for innovation facilities. In one example, a stakeholder turned to food and beverage innovation facilities for their technically advanced manufacturing extraction process because it was dealing with plant products.

The types of innovators accessing facilities vary in both size and need; however, access is typically skewed toward smaller innovators. This may seem intuitive since larger, well-established innovators likely can afford most of their own facilities and have the capability and capacity to innovate within-house. Innovators also have a spectrum of needs. Small innovators often need to be pointed in the right direction and taken through the entire innovation process, whereas larger innovators that are more established may have the capacity and capability, but just require discrete access to hyper-specific equipment they do not own.

Potentially some duplication of resources across different facilities, but also nuance that must be appreciated

Some stakeholders believed there was unnecessary duplication of resources across different innovation facilities within the advanced manufacturing sector. If true, resource duplication can ultimately lead to unnecessary expenditure and trickle down into higher equipment use costs (since facilities will price depreciation into access costs). One stakeholder commented that this a problem not only across facilities, but within institutions as well, claiming the university they are a part of has 10 of the same pieces of equipment sitting in different departments. Part of this duplication could be due to poor internal visibility of resource, and also gatekeeping by certain departments and facilities (i.e. excluding external use purposely).

One stakeholder said it is important to note that while a layman may suspect duplication of resources across departments/facilities, there are often nuances in the use and specification of the resource that serve very different purposes. The extent to which this is true or applies to the general sector is unclear and requires further analysis before any robust conclusion can be made.

Scalability appears to be a problem in advanced manufacturing

Scalability is an issue that arises across all target sectors. For advanced manufacturing, stakeholders said that innovation facilities are typically useful for bench-scale concept development but lack scale-up and pilot facilities to convert proven concepts into commercialised products. Part of this may be driven by the typically high cost and space requirements for new innovation facilities (e.g. titanium furnaces, large steel mills, etc) and the lack of capability to expand easily, as well as the existing gaps in scale-up facilities being in niche, low-use areas of advanced manufacturing.[49]

This issue was only raised by a few stakeholders; therefore, it is unclear how widespread the lack of scale-up facilities/options is. Future research may uncover if this is an industry-wide problem that can be addressed by government intervention.

Speed of access to and process of advanced manufacturing innovation facilities is slow

Almost all stakeholders accessing advanced manufacturing facilities said the speed of access to facilities is slow and typically does not align with the innovation cycle, or the need to get to market as quick as possible. There are a few suggested drivers for this:

- Dual mandates of university and university-associated facilities (also Callaghan and the MacDiarmid Institute to some extent).
- Misalignment of commercial needs by going for the gold-standard outcome, instead of the minimum viable product that will be successful.
- Capacity constraints that increase wait times.

Firstly, dual mandates of universities and university-associated facilities (as well as Callaghan and the MacDiarmid Institute to some extent) can drive time delays and slow down the speed at which innovators can access advanced manufacturing innovation facilities and increase the time taken to go through the innovation process. This is for two reasons, also identified elsewhere: teaching and research priorities and mandates, as well as career progression incentives through publications.

Commercial innovation work typically takes a backseat to teaching responsibilities and academics' research interests because those are the primary requirements of academics. This results in drawn-out timelines for innovation projects. Others talked about how academics involved in commercial innovation projects typically want to make projects into something much bigger than they need to be because of publications. In one example, a stakeholder mentioned a project that should have only taken six weeks but got turned into three full concurrent PhD projects. Stakeholders said there were some facilities that do not have research outcomes or objectives as their key drivers, which makes the relationship easier.

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[49] This lack of capability to expand may also come down to financial decision making. Innovation facilities may not see positive benefits from investing in large-scale facilities if they will not be utilised at an appropriate rate (i.e. low use in niche areas of advanced manufacturing).

Stakeholders in the 2011 MSI report commented that the research-output incentives for academics specifically are a major barrier to collaboration since they go against industry need for quick turnarounds. This is clearly still an issue a decade later.

Secondly, stakeholders mentioned how academics and career researchers are often misaligned with commercial needs by going for the gold-standard outcome for the innovation (i.e. increasing the time taken to get through the innovation process), instead of the minimum viable product that will be successful in the market. Anytime the timeframe gets extended on an innovation process, the level of risk of failure increases since competitors could enter the same space in the market earlier and close out the stakeholder. The misalignment is because of intrinsic differences in approaches between academic and industry research, and not something that can necessarily be fixed easily.[50]

This issue of misaligned timelines between facilities and innovators was recognised in the 2011 MSI report as well as in current stakeholders' experiences.

Thirdly, capacity at innovation facilities is often limited. Sometimes this is because of the dual mandates and responsibilities of academics mentioned earlier; other times it is simply because of excess demand, and facilities do not have the time or resource to be able to commit to innovation projects.

A stakeholder in the 2011 MSI report said that universities get paid to teach and research, but not for engagement with industry and commercialisation activities. If persistent, this may be a further driver of current capacity constraints at university and university-based innovation facilities.

Some innovation facilities feel conflicted when providing services to innovators

Two stakeholder groups shared their reluctance to provide services to innovators at public facilities because they fear they are crowding out private providers that are reliant on this type of work as their main income. In both cases, the examples of conflict arose with 3D printing and performing discrete fee-for-service jobs that were associated with the innovation process but were not necessarily true innovation activities. Importantly, this could suggest that innovators approaching public facilities for these sorts of projects may not initially be aware of the alternatives that exist within the market, both publicly and privately. Clearly, this sort of activity could restrict capacity at public innovation facilities for true innovation processes.

Range of engagement channels for building innovation relationships/partnerships at facilities

A large focus of engagement is about building partnerships that provide long-term mutual benefits. There are numerous ways of engagement that stakeholders use to build innovation relationships/partnerships, including:

- membership model that grants access to certain expertise and facilities
- personal networking/relationships
- student research projects in collaboration with industry for final year projects

[50] In other words, academics are typically passionate about research and want to be able to fully understand a problem and its parameters, therefore want to go the extra steps further than a 'good enough' outcome.

- research offices at universities and customer engagement managers at other facilities.

One stakeholder uses a membership model that provides members with access to innovation facilities and expertise. This operates within a specific sub-section of advanced manufacturing and seems to be well socialised among industry participants.

Most stakeholders recognised personal networking as a significant way of forming innovation relationships/partnerships. These personal relationships are generally driven through previous employment, academia, and by having world-leading expertise. Innovators often approach academics directly who are renowned for being specialised in certain areas of advanced manufacturing.

A more formalised but often still relatively unsystematic pathway of engagement with innovators is through students' final year projects at universities. As one stakeholder put it, this is sometimes used to test the water and develop long-term relationships. It also gives innovators the chance to tap into student and supervisor knowledge as well as university facilities that otherwise may not have been accessible.

The most formal engagement channel is through university research offices and customer engagement managers at other facilities that reach out and engage with industry, serving to be a bridging link for collaborating. This is a systematic approach to engagement with innovators and provides a clear and well-trodden pathway into facility access.

The 2011 MSI report stated that there was a lack of "translators" who bridge the gap between businesses and providers of research services, and a "passive" approach that requires innovators to hunt for help. Current stakeholder experiences suggest there has been progress made in developing these sorts of roles and a more forward approach, as seen above with customer engagement managers and research offices that go out to industry to form relationships.

8.2 Information availability, sharing, and use

Section summary

- Awareness of facilities and capabilities is not good for both accessors and providers.
- There is a sense of naivety around access to innovation facilities in the advanced manufacturing sector.
- Capability/expertise and capacity are limited in New Zealand for some niche areas of advanced manufacturing.

Awareness of existing innovation facilities is not good

In general, it seems that awareness of advanced manufacturing innovation facilities and capabilities amongst stakeholders (both accessors and providers) is not good.[51] This has clear impacts on the ability for innovators to commercialise their ideas in a timely manner, which ultimately affects the New

[51] Two stakeholders suggested there was decent awareness of facilities, however in the context of the relevant advanced manufacturing activities and facilities, this is likely localised due to the stakeholders' personal networks, experiences, and past employment roles.

Zealand economy. Stakeholders commented that it is typically hard to find facilities that suit their needs, as well as alternative options domestically. Also, smaller innovators unfamiliar with the innovation process generally do not know what opportunities are available for them, particularly if they have not had any experience with universities or academia previously. At least with some sort of university background, innovators typically have a starting point in their search (i.e. contacting some department). To be able to know what exists, innovators need to know what to ask for and what to look for – which often is not the case.

New Zealand is small enough that facilities (and therefore alternatives) do not exist at all in some areas of advanced manufacturing, which further compounds issues around awareness (i.e. people engage in costly, time-consuming searches for New Zealand facilities, despite being unaware they do not exist domestically).

This issue plays out on both sides of stakeholders – a few providers suggested fragmentation and silo mentalities of different innovation facilities result in limited inter-facility interaction and therefore limited awareness of what facilities and capabilities exist elsewhere, as well as what research is being conducted.[52] As a result, there can be duplication of resourcing and equipment as well as inefficient use of facilities, particularly if the facilities best suited for the work are not matched to the most appropriate need. Additionally, providers recognise they do not socialise their capabilities and facilities well to innovators; however, they have been trying. As other stakeholders have suggested, socialising current capabilities and facilities is inherently difficult because of the:

- speed at which capabilities and facilities can change
- large number of capabilities and facilities that exist (and therefore, the potentially large duplication in listing across different facilities)
- breadth of what capabilities and facilities are defined as.

In the 2011 MSI report, submissions highlighted that a lack of awareness of capabilities, and lack of networking and collaboration between organisations (including between research organisations throughout the country) was a barrier to R&D uptake and access. Additionally, stakeholders said there was no research organisation in New Zealand focused on servicing the needs and issues of the high value manufacturing sector, and there was a lack of (or poorly developed) clusters of expertise. Comparatively, it seems that there are now research organisations that are focused on servicing the needs and issues of the high value manufacturing sector (such as Callaghan), but there are still issues with awareness, networking, and collaboration between organisations and clustering of expertise, highlighted by the current stakeholders' experiences with siloed information and fragmentation.

Naivety of innovators and providers in advanced manufacturing

Naivety of innovators and providers in advanced manufacturing was raised by numerous stakeholders as an issue surrounding access to facilities. The naivety was showcased in three main domains, but it may not be limited to these only:

[52] For example, across different universities but for similar departments (e.g. engineering), there is often no strong linkage and therefore no good awareness of what others are working on, or the capabilities and facilities they are able to provide.

- ill recognition of the importance of literature and patent information in informing innovation approach
- IP management and recognition
- costing of access to facilities, and the hidden costs of different arrangements with facilities.

A stakeholder said innovators that access their facilities often neglect extant literature and patent information as a valuable source of information when developing their innovation approach. Part of this may be because innovators do not know where or how to find literature and patent information. It may also be because the value of conducting a literature and/or patent search and review is not fully realised.

In the 2011 MSI report, some respondents said businesses do not see the need to engage in R&D and that businesses fail to see the benefits that can come from R&D and innovation. Although literature and/or patent searches are only a small part of R&D, this suggests the problem could be ongoing and innovators are still not seeing the value in engaging with R&D.

One stakeholder commented on a lack of knowledge among innovators and providers in recognition, management, and protection of IP. IP leakage has been identified as a significant concern for both innovators and facilities and may act as a barrier to access. The stakeholder said that often information is shared between facilities and innovators when it really should not be because of naivety and ill understanding, plus lack of education of what IP really is within different contexts. This may have been driven by New Zealand's historically laid-back approach to IP management and patent outputs. However, modern funding mechanisms require that research considers this.

The third area of naivety highlighted was around the costing of access to facilities and the hidden costs of different arrangements. Some providers of university facilities said that innovators have an expectation to be able to get access at a cheaper rate from universities than from a consultant, perhaps because they are publicly funded. The providers also said that innovators assume universities can operate like consultants, which is generally not true due to mandates. In cases where the consultant (private) facilities are a good substitute in terms of capabilities and equipment, they would be preferrable because they are more commercially focused and likely do not have teaching and/or other research responsibilities like a university does. As a result, the consultant facilities likely run at higher utilisation rates and can complete work at greater speeds, resulting in lower costs of access.

When innovators access university facilities, their projects are being juggled with other activities (research and teaching) that can take priority, resulting in extensions to timelines and higher costs (through lower utilisation rates, less commercially focused and efficient facilities, and university overhead structures). In some cases, innovators access university facilities with the expectation of getting access to expert professors; however, due to commitments and/or other interests, innovators often end up with PhD students working on their project and therefore sometimes a lower level of analysis and rigour.[53]

[53] In this case, there is an unrecognised difference in the innovator's expected quality of access (accessing a professor's time) and the true quality of access (getting a PhD student's work) when engaging with university facilities. As a result, outcomes for the innovator are lower than expected.

In other examples, innovators access university innovation facilities to use relatively cheap student time and expect to own all IP at the end of the project. The innovators fail to realise the trade-offs being made between cost of access and IP ownership when they opt to hire students at university facilities. Student time is relatively cheap to buy out compared to established academics and therefore innovators may see it as a preferrable option (since they get access to the student's supervisor's time as well as the facilities too); however, they do not consider the implications that has for the IP generated from the project. By accessing student time instead of an established academics, innovators are not paying the full cost of the research.[54] In some cases, this means that shared IP arrangements are desired from the university side, particularly if the student needs to publish work for part of their degree.

Two university stakeholders in the 2011 MSI report said companies/innovators were unwilling to pay going rates for R&D and, due to little or no experience investing in R&D, perceived the cost of contract R&D in New Zealand to be high, when it is actually relatively low internationally. Although not discussed explicitly among current stakeholders, this suggests that the naivety amongst innovators currently with regard to costing may not be a new issue and there may be a systematic issue about education and the unrealised importance of R&D within the innovation process.

Capacity and capability limited in some particularly niche areas

There is likely limited capability and a shortage of expertise domestically for some particularly niche areas of advanced manufacturing that could threaten facilities' future capacity and capability to help innovative firms. One specific area is in electromagnetism. This problem has already been present prior to COVID-19, which suggests it is likely a more systematic problem with New Zealand's ability to develop and retain human capital in these areas. In other areas where there is capability in niche areas, facilities and expertise are often overrun and in high demand.

In the 2011 MSI report some stakeholders commented that the main barrier to using R&D from research organisations was that their R&D requirements were in niche areas, and therefore the firm and not an external supplier had the most expertise. It seems this has not changed over time given current stakeholders' experiences. However, addressing this issue will be inherently difficult because of New Zealand's small scale in the global ecosystem (i.e. New Zealand cannot be good at everything as we do not enjoy the economies of scale required to do so).

[54] Effectively, the cost of access the innovator expects is the cost of student time alone. This may seem like a good deal when considering the access also gained to the supervisor's time as well as the facilities, however the hidden cost of this access is the IP control loss when a shared arrangement is set up. If innovators were aware of this from the start, they may be more willing to pay higher costs of access at the start of the project for established academics' time to ensure full IP control post-project. There is a trade-off between short term gains (avoided costs) and long-term losses (less IP revenue in future).

8.3 Administration processes

Section summary

- The cost to access innovation facilities is variable and perhaps prohibitive in some circumstances.
- IP management is complex and can cause issues, calling for a greater need for education.
- Funding can be hard to secure for both accessors and providers, which threatens future access and capability.

Cost of access is variable and perhaps prohibitive in some circumstances

In some cases for some facilities, access is not priced at all and small discrete pieces of work are conducted when facilities have free time, sometimes by students if at universities. Other times facilities have formal costing models, but they also vary dependent on a multitude of things such as the type of work, nature and length of the relationship, and the complexity of the work.

When access is priced, cost of access is generally variable and largely depends on the area of specialisation. In some cases, equipment required by innovators is highly specialised and may not be readily provided by innovation facilities or used very rarely. As a result, access costs can be higher because of lower utilisation rates (i.e. lack of economies of scale). For example, one stakeholder said the costs in New Zealand were at least four times the price of the same work in China because of the niche of the project and the lack of facilities and capabilities domestically. In other cases, the facilities and expertise required can be relatively general and therefore equipment enjoys economies of scale (higher utilisation rates) and lower use-costs.

One stakeholder suggested resource duplication across facilities (particularly duplication of multi-use equipment within different departments of the same facility) can lead to higher use costs and therefore inefficiencies in access that may turn some people away from using innovation facilities. For example, if every department of a facility had its own scanning electron microscope, each department would have to price depreciation and purchase cost into their access costs for innovators. This would likely lead to higher access costs for innovators than if the departments had a pooled scanning electron microscope that can be used and accessed by all departments.[55] Another stakeholder from a university suggested innovators may find the costs of access to university innovation facilities prohibitive, particularly because of university overhead cost components.

Nearly every stakeholder from the 2011 MSI report said that the costs of R&D (initial cost of research, cost of implementation, cost of accessing support mechanisms i.e. grant applications, ongoing costs of R&D) were barriers to uptake in R&D and access. Although not widespread in our consultation, one

[55] This assumes that by pooling resource and having a shared scanning electron microscope, there would be a) lower level of equipment purchase and depreciation costs to be priced into access costs, b) a wider base of accessors to spread equipment purchase and depreciation costs across, c) higher utilisation rates of the scanning electron microscope and therefore lower costs per use.

stakeholder said that the costs of access may be prohibitive, suggesting that in pockets of innovators, cost of access may still be a barrier.

IP complexities can cause issues; greater education around IP needed

IP control plus management is a significant issue raised by both accessors and providers and is sometimes seen as a barrier to access. Some stakeholders told of their experiences with innovators who were reluctant to engage with innovation facilities (or proved to be difficult to work with) because of previous issues with IP leakage and mismanagement.

There is a lot of variability in the way IP is managed and shared among innovators and facilities, likely dependent on the mandate of the facilities. Some facilities have standardised channels for dealing with IP, such as research offices or IP managers, and outright policies of signing non-disclosure agreements to manage concerns as best as possible, but IP is an inherently complex landscape and therefore issues can still be encountered. Some facilities have clear policies about IP ownership that enable the innovator to capture all IP; others are less so. In some cases, innovators' expectation to be able to own all IP can cause issues and sour relationships despite that arrangement not always being possible.

Multiple stakeholders suggested there needs to be greater education about IP for both innovators and providers of facilities to ensure the relationships and agreements are as smooth as possible and that IP management does not pose as a barrier to access innovation facilities. This education must include discussion about how IP management works at different facilities and how it interacts with different mandates (such as universities and the need for students to publish work), as well as the benefits of licensed IP compared to ownership of IP.

In the 2011 MSI report there was considerable mention of IP management, potential leakage, and ownership arrangements as issues and how it poses a barrier to innovators conducting R&D with research organisations. Clearly, this issue is ongoing.

Funding can be hard to secure for both innovators and facilities and therefore threatens future capabilities

Publicly available funding is instrumental for innovators to be able to access innovation facilities and commercialise their ideas. Innovators said that access would not have been possible without funding. Others, however, said that funding from MBIE or the Endeavour fund specifically was often hard to secure, particularly if the innovation was not considered novel or "blue skies". The root of this is unclear; however, it likely lies within the priorities of the government and the research outcomes it desires, as well as those of the fund managers.

Public funding is also instrumental in maintaining capability and capacity at innovation facilities within the advanced manufacturing sector. Particularly at universities, research grants from the likes of the Endeavour and Catalyst funds directly pay for capability and capacity within facilities. This means that if funding cannot be secured, there is no other way to pay for the capability and capacity and therefore it must be let go (often referred to as "soft money"). Academics must therefore spend a significant amount of time and effort to try to secure funding.[56] As a result of the significant effort required, one stakeholder told us academics often "do not get out of bed for less than $100,000 funding", or in other words, they are not going to go to the effort of writing a grant application for a small project.

One stakeholder recognised great uncertainty in their future ability to secure funding for advanced manufacturing research due to recent grant allocations being consolidated to other sectors. As the government priorities change, so do the funding allocations. Without clear indication of what the priorities of the government are when it comes to research and innovation, those that rely on grants to get by may find themselves spending significant amounts of time and effort with no return and ultimately no future capacity and/or capability. Stakeholders request visibility of the funding available, and how it will be allocated to know how to align their research for the best outcomes.

Clearly, no capacity or capability to provide innovation facilities and expertise would result in fewer innovators being able to access public facilities and likely less than ideal outcomes for the New Zealand economy.

Stakeholders in the 2011 MSI report identified a lack of money (from both themselves and government investment) available to research and commercialise ideas, and some SMEs said they do not have the capacity to fund research. Current stakeholder views suggest that this is persistent, and that some innovators are unable to access R&D and innovation facilities because of a lack of money. A stakeholder in the 2011 MSI report also said the grant process was a "pain in the neck" and a lot of effort for small grants, which suggests this is a persistent issue.

[56] This further complicates the relationship academics at universities or university-based facilities have with the innovation process, since their capacity to help innovators is already constrained by teaching and other research mandates.

9. Expectations about future demand for advanced manufacturing facilities

As with the other sectors, forecasting future demand for advanced manufacturing innovation facilities is inherently difficult. There are, however, some comments that can be made about future demand expectations, given current stakeholder experiences, literature, and the 2011 MSI report.

Niche innovators have struggled with access and will likely continue to do so due to New Zealand's size

Innovators operating in niche areas of advanced manufacturing have told us that they struggle to get access to innovation facilities and expertise because it often does not exist domestically, or if it does, it is at capacity. This issue was identified in the 2011 MSI report and in our analysis of access to innovation facilities, suggesting it is an ongoing, systematic problem to do with the labour market and New Zealand's inability to generate and/or retain the required human capital to make these things happen.

This nods toward New Zealand's relative size on the global scale as well. As a small market, New Zealand is generally unable to provide for every avenue, particularly in areas where New Zealand does not enjoy comparative advantage or economies of scale. It is possible that niche innovators within advanced manufacturing are innovating in areas that New Zealand is typically not strong at producing, and therefore has not received focus by the government and subsequently no funding.

As a result, innovators that continue to occupy these niches will likely continue to struggle to access innovation facilities and expertise, unless the niche areas become a focus of the New Zealand government and receive funding.

Capacity is constrained at facilities, and without some form of change may continue to be

It seems there is excess demand for innovation facilities within the advanced manufacturing sector. Since the speed of process at innovation facilities is typically slow, this could drive capacity constraints. With limited capacity initially, if the process of going through a facility for innovation is slow, those that can access will effectively be closing out other innovators from accessing (i.e. higher wait times for others due to slow processes).

Additionally, the dual mandates of universities or university-associated facilities mean innovation work is traded off with teaching and research, which constrains capacity further and can feed into the slower speed of process at innovation facilities.

Without some form of change to speed up the process of innovation facilities, or increase capacity available for innovators to access, there may continue to be excess demand.

Lack of scale-up facilities in advanced manufacturing; nowhere for some innovators to go

Some stakeholders said there are no scale-up options for innovators in certain areas of advanced manufacturing. This issue is again fundamentally difficult to unpack and address because it is unclear how widespread this issue is across advanced manufacturing and whether it solely exists within niche areas.[57]

Most importantly, however, is that where there is a lack of scale-up facilities, the capital and space required to invest/obtain them is significant and prohibitive for innovators. Again, if there is no change, there will continue to be excess demand for scale-up facilities and no supply.

The implications of missing capacity and/or shortages in advanced manufacturing facilities could be significant. Where no capacity exists or is constrained, innovators may be required to turn to international markets. This may have negative effects on the New Zealand economy and forfeit any benefits from innovating here (cluster benefits, local GDP growth, etc).

[57] If it is solely an issue within niche areas of advanced manufacturing, that may further complicate the issues discussed previously in this section. If it is a wider problem and there is a lack of scale-up facilities for a wide range of advanced manufacturing activities, then there may be some remedy available.

10. Forestry and wood processing sector

The government supports access to forestry and wood processing innovation facilities directly and indirectly through a range of policy settings. Examples include:

- funding basic and applied research and determining their incentives
- through its governance and funding arrangements
- incentivising firms' business R&D (through grants and tax credits), e.g. the $431 million RDTI which firms can use for R&D working with Scion or the University of Canterbury
- supporting new ventures, for example, through the Sustainable Food & Fibre Futures Fund.

10.1 Stocktake of innovation facilities

The two key (largely) government-funded innovation facilities in the forestry and wood processing target sector in New Zealand are:

- Scion
- the University of Canterbury – the College of Engineering, the School of Forestry, and the Wood Technology Research Centre.

Additional fringe forestry research facilities include:

- Farmed Landscape Research
- Biochar Research Centre
- New Zealand Centre for Precision Agriculture
- Poplar & Willow Research Trust.

Scion

Scion is the key largely government-funded CRI in the forestry sector. The key government intervention that supports access to Scion's innovation facilities, as is the case for the other CRIs, is through a mix of core funding (from the SSIF), contestable funding and contracts with government agencies. Scion's funding share from government is above the average level of the seven CRIs. The government funds 79 per cent of Scion's revenue, which totalled $61.08 million in 2021.[58]

University of Canterbury – College of Engineering, School of Forestry, and the Wood Technology Research Centre

The University of Canterbury is the second major innovation facility in the forestry and wood processing sector. The University offers an alternative research option to Scion and is the only university in New Zealand that offers professional forestry degree programmes. Public funding for research is primarily through the PBRF.[59]

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[58] Scion Annual Report 2021 Highlights, September 2021, Page 44

[59] PBRF – Performance Based Research Fund.

Farmed Landscapes Research

The Farmed Landscapes Research works with industry, government bodies, and private entities to conduct novel research, undertake product evaluations, analyse soil, plant and water samples, and investigate issues identified in the primary production sectors (Massey, 2021).

Biochar Research Centre

The internationally recognised Biochar Research Centre researches the use of biochar to mitigate climate change and to enable its use in New Zealand (Massey, 2021).

New Zealand Centre for Precision Agriculture

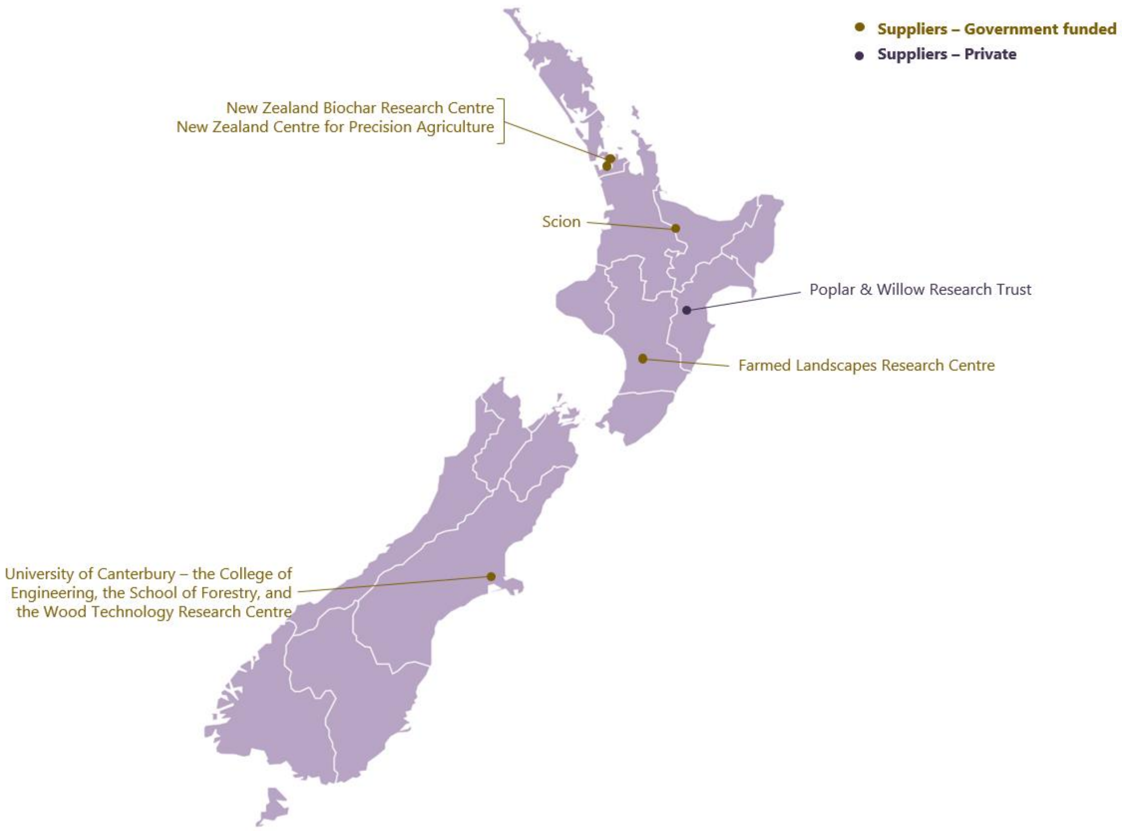
The New Zealand Centre for Precision Agriculture increases the economic and environmental performance of land by creating practical land management solutions (Massey, 2021).

Poplar & Willow Research Trust

The Poplar & Willow Research Trust ensures the funding for research in breeding and applied science for poplars and willows for the public good of New Zealand (Poplar & Willow Research Trust, 2021).

Additional detail on the activities and services offered by these research institutes can be found in Appendix D.

Figure 5: Location of forestry and wood processing innovation facilities



11. Forestry and wood processing stakeholder experiences

Sapere, alongside forestry consultant John Schrider, interviewed 19 stakeholders (two of these were via exchanges of emails). The following section outlines the key themes found from these interviews. A detailed list of evidence from interviews can be found in Appendix D.

11.1 Demand, relationships, and engagement

Section summary

- Speed of access is slow.
- Distinct lack of scale-up facilities, though provision of such facilities is difficult.
- Focus should be on industry problems.
- Engagement is usually through informal channels or existing personal relationships.

Speed of access and process is typically slow

Many users reported that the speed of accessing innovation facilities was slow. Attempts to engage with Scion are friendly and appear to be successful; however, there tend to be lots of nodding and smiling faces, but nothing happens. This tends to delay existing innovation and disincentivise future research. This perception of a lack of speed has meant there is a reported inbuilt expectation of long timeframes, so innovators who want anything within a short period of time will not use Scion as an innovation facility.

This lack of speed could be partially attributable to rigour of process. Facilities were reported to follow a rigorous process, which, although potentially increasing the value of research, leads to extended periods of time before research is able to be utilised by innovators.

These comments from interviewees paint a picture of a tendency for a lack of responsiveness to the speed often required by private sector firms and trusts seeking to innovate. However, there is an inherent trade-off to be managed here. Spending too little time on process could lead to facilities focusing on research which could turn out to be low priority if not properly vetted first. On the other hand spending too much time on process disincentivises research from occurring in the first place and sees firms look to use other facilities, even offshore ones.

Distinct lack of scale-up facilities, though provision of such facilities is difficult

There is a distinct lack of scale-up facilities in some parts of the forestry and wood processing sector – for example, a scale-up plant for use with non-food-grade biomass. Some users reported the biggest obstacle to innovation as being the gap between laboratory and commercialisation. A scale-up facility could bridge this gap, de-risking innovation and allowing the potential economic returns from innovation to be realised. One example of this gap included the need to purchase $100,000 of stainless steel to bring a product to market. Without provision, the start-up bears almost all the risk by financing the stainless steel, where if the project went wrong, it would likely bankrupt the company. If the stainless steel was able to be hired from a scale-up facility, there would be less risk borne by the start-up, and they could be much more inclined to invest in the project.

The scale up facility gap in New Zealand's was compared to other countries. All other major primary industry countries were stated to have some form of (largely publicly funded) bio pilot facility. However, Scion is working in partnership with a German research institute, scoping what sort of bio pilot facility might work best in New Zealand. This German institute runs the largest bio pilot facility in Europe and Scion is leveraging this relationship to establish which specific equipment could be needed here.

Our interviews suggested that forestry and wood processing innovation projects were often quite unique, with each project generally requiring project specific skills and equipment depending on the objective of the research work. This specificity means it is often difficult to find equipment applicable to a range of projects and therefore difficult to achieve economies of scale in scale up work. The varying demand for equipment means it is challenging to make an economic case to purchase equipment for a scale up facility. Creating a facility in the sector that sought to provide piloting or commercialisation scale will require careful consideration to ensure the equipment purchased has a low probably of being a stranded asset and meets an acceptable level of self-funding. Given the experience of the FIN's Food Bowl, its seems very likely to involve a high proportion of government underwrite of the plant's commercial risk.

Focus should be on industry problems

Innovation research should focus on solving industry problems for that part of Scion's work that is not directly driven by Government funding towards non-commercial goals. We heard some industry frustration about scientists prioritising publishing their research over other research priorities. We were told by some that historically, innovation research has followed scientists' personal agendas, rather than meeting the needs of industry. Scientists from an academic environment were said to be focused on investigator led approaches, rather than on mission-led problems i.e. solving industry problems. According to some, this tendency de-prioritised innovation that would otherwise be important, shifting the focus towards the institutes' self-interests and away from New Zealand's.

However, from the perspective of those providing the research, the counter argument is that publication ensures research is communicated and assists innovation in that way. In the view of the providers of research, publishing in world renowned journals means innovation research is world leading and world standard. It also acts as a mechanism to ensure research is of top quality and globally relevant.

We heard a variety of opinions on what the sector's research institutions should be focusing on. These opinions could be categorised by disaggregating innovation into the three horizons, i.e. Horizon 1 involving adapting a firm's existing innovations, Horizon 2 involving extending a firm's existing innovations, and Horizon 3 involving creating entirely new innovations, (Harvard Business Review, 2019). A view expressed by some was that Crown research institutes should focus on Horizon's 1 and 2 i.e. the adaption of existing innovations to a New Zealand context. In contrast, universities were generally recommended to focus on Horizon 3 i.e. entirely new discoveries. An influential interviewee strongly suggested that to avoid getting outpaced and out resourced by the rest of the world, Horizon 3 research in the forestry sector must focus on areas where New Zealand has a comparative advantage. This means working to New Zealand's strengths and leaving certain areas on the edge of scientific discovery to overseas entities.

A counter view from an interviewee within a key supplier of research in the sector was that often the capability for New Zealand to pursue effective Horizon 3 research was very dependent on the serendipitous availability of personnel working at the frontier of science in their particular discipline. Sometimes, for a wide range of reasons, personnel of high potential value could become available and open up an opportunity for research in areas in which New Zealand might not be seen to have a strong competitive advantage.

Our interviews highlighted some of the key issues in Scion's historic methods of operation rather than its current approaches. Scion's more recent strategy appears to have lifted its focus on communicating with the industry and seeking to maximise the value added to New Zealand. This new approach has put an emphasis on understanding the needs of the industry. According to some of those we interviewed, this change is only recent, occurring within the last year, so the impact of this shift has not played out.

Engagement is usually through informal channels or existing personal relationships

Our interviews underlined the extent effective user engagement with research institutions is usually through informal channels or existing personal relationships. Larger and long-time users of innovation facilities reported the majority of their access to facilities is through existing personal contacts. The personal relationships developed over time enable effective engagement with the right people within an innovation facility and reduce search costs for these firms. One user stated that when venturing into an unknown area, their relationship was good enough that the institution's staff will run around and sort them out.

However, this is not the situation for new or smaller innovators. These firms usually lack established relationships. Many of these first time users reported significant difficulty in accessing the right people, knowing where to go, and what equipment was on offer. This lack of effective communication between research institutions and first time (and often smaller) users inhibits access to facilities and therefore the value from them.

Section summary

- Small to medium users face difficulties in accessing innovation facilities.

Small to medium users face access issues

Small to medium users reported difficulty in accessing innovation facilities. According to them they appear to face de-prioritisation as a result of commercial funding drivers. Larger scale projects are more likely to generate larger amounts of revenue, given the sums of money involved, and therefore are prioritised by research institutions. Additionally, there is a lower risk to reward ratio in dealing with well-established players i.e. it is a lot easier to add $1 billion to an existing $5 billion industry, than to create a $1 billion industry from the ground up. Our interviews suggested that these two factors combine to influence the decision making of research institutions which ultimately leads to small to medium users facing a lower prioritisation and reporting more difficult access issues.

The prioritisation of larger firms and larger projects could result in arguably less risky, more valuable outcomes. Research institutions are faced with balancing the risk of disincentivising 'blue skies', perceived risky innovation, with the risk of not maximising value added to New Zealand. However, if research institutions aren't incentivised to deal with the new and small industry players, then they are likely to continue to lack priority.

11.2 Facility processes

Section summary

- There are complexities in the way IP is handled.
- Costs can be significantly greater than overseas.

There are complexities in the way IP is handled

Users of innovation facilities reported feeling disincentivised with the way IP was handled. Research facilities' approach was said to be inflexible and dogmatic. Users felt that because they had the original idea and funded the research, they should be entitled to the IP generated from the research, or at least to a large share of it. Ownership of the IP allows for the profits of the research to be realised, meaning inappropriate handling of IP takes the profits away from users and disincentives innovation research.

Comparisons were made with similar overseas research institutions. One user reported a much more positive experience when dealing with a European institute with a commercial arm, the institute was open, and the sharing of the IP was balanced and flexible. The same user reported a contrasting experience in New Zealand, stating they felt like the research institute was only out for themselves. This example was not isolated, with other users we interviewed reporting similar experiences. This risks New Zealand innovators being more inclined to go overseas with their research, or not using existing facilities by devising their own approaches to research, which could reduce returns to New Zealand over time.

However, the use of public funding means there needs to be a consequence of IP i.e. some benefit to New Zealand outside of the private benefit received by the innovator. The primary means to do this is for the research institute to get some share of the benefits. Another pressure is to share this IP with other similar New Zealand organisations. CRIs must source funding outside that provided from the government through independent revenue streams. A primary means of doing this is by licensing IP. The example of Zespri's licensing of kiwifruit varieties where Plant & Food Research held the IP and were able to receive approximately $30 million in royalties was pointed to as problematic for other CRIs because they were not in a position to emulate this arrangement. So, CRIs aimed to replicate this model to generate their own sources of income, but in doing so, they could be too inflexible and seek too much value relative to the expectations of private firms.

We note that some of our interviews of research providers suggested that there have been recent changes which could address this perception by users of inflexibility in provider approaches to IP negotiations. Over the last 18 months, Scion have made efforts to refresh their strategy with a greater focus on maximising the benefit to New Zealand. One aspect of this is their approach to IP, where it has made efforts to ensure future IP transaction are more commercially realistic and are as seamless as possible.

Costs can be significantly greater than overseas

The cost of using innovation facilities in forestry and wood processing is reported to be significantly higher than overseas. Users reported being disincentivised by the high relative cost of New Zealand innovation facilities. One user received quotes four to five times that of an equivalent agency in Europe, where the New Zealand service did not come with certification and the European service did. This experience was far from isolated, with other users also reporting faster, better quality, and cheaper services offshore.

A portion of this cost is unavoidable. Because New Zealand is a relatively isolated country with a low population, it cannot achieve the same economics of scale as some of the larger, more wealthy European countries. Innovation research is more costly to complete, where this cost is passed down to innovators in the form of higher fees. The complexities of forestry and wood processing innovations means these factors are compounded. The high cost nature of resources means it would not be feasible for New Zealand facilities to provide these suitable facilities.

It is difficult to know for sure the extent this problem in exacerbated by the approach of New Zealand research providers. It is likely a certain amount of research would be done offshore even if Scion's IP approach were optimised from an innovator's point of view. However, it does suggest that there is a need for Scion to focus on responding to new and smaller firms needs and communicating and interacting with them more effectively.

12. Expectations of future demand for forestry and wood facilities

Section summary

- Scion's three core areas of future focus are the best available to forecast expected future demand, these areas include forest and landscapes, forest to timber products, and forests to biobased products.

Scion's assessment of current and future demand for access to its innovation facilities is reflected in its key strategic documents such as its Statement of Corporate Intent. Scion has recently organised itself around three impact areas and 11 portfolios as follows:[60]

- Impact area 1 – **Forests and landscapes**. This is comprised of the following three portfolios:
  - Establishing indigenous forests
  - Restoration, protection and mauri of Te Waonui a Tane
  - Designing forests – Mahi Tahi Whaihua.
- Impact Area 2 – **Forests to timber products**. This area has four portfolios:
  - Trees to high-volume wood products
  - Trees to high-value wood products
  - Indigenous trees for distinct value wood products
  - New value digital forests and wood sector.
- Impact Area 3 – **Forests to biobased products**. This area is made up of four portfolios:
  - High-value biorefineries
  - Bioproducts and packaging
  - Distributed and circular manufacturing
  - Integrated bioenergy.

In the next section we take each portfolio in turn and examine Scion's plans to fulfil demand for its innovation facilities. We examine these facilities at a functional level and where possible, comment on the products that are expected to be the focus of demand. Information on capacity, usage, products supported, and scale throughput was difficult to access. All facilities are accessible by non-owners but as discussed above, prioritisation of access will sometimes mean projects involving larger funders will take precedence over private or trust funded research.

[60] Scion Statement of Corporate Intent 2021 -2024

Impact area 1 – Forests and landscapes

Establishing indigenous forests

This will involve firms accessing Scion's research facilities that range from germplasm selection and seedling propagation, through to establishment of successfully growing forests at canopy closure. The use of mixed-use forests with under-story crops is also included in this portfolio. Research in this area will focus on growing healthy nursery plants using automation, as well as breeding and disease monitoring. Relevant innovation facilities will also be seeking to understand the ecophysiology of climate, soil weeds and microbiome on healthy forest establishment. Databases to understand regional genetics, the role of eco-source boundaries, seed industries will also be a focus.

Scion sees the key entities that will want access to its innovation facilities for this portfolio as being Māori landowners and environmental afforestation companies along with government funded entities.

Restoration, protection and mauri of Te Waonui a Tane

Scion believes that research in this area will focus on existing indigenous forests and developing adaptive forest management. Innovation facilities in this portfolio will be used for work on new biosecurity technologies, understanding wildfire risks and solutions to pathogen risks including detection, spread and diagnosis.

Māori landowners and environmental afforestation companies are predicted to be the key entities that will want access to Scion's innovation facilities under this portfolio. Recently the Forest Growers Research, representing levy payers, has funded research into wildfire behaviour using specialist camera equipment and drones.[61] This funding is of importance given the anticipated increased risk of wildfires from climate change.

The views of those we interviewed suggests that Scion's approach to future demand under this Impact area is reasonable. Some aspects of it are more driven by government priorities rather than private sector priorities for example the focus on indigenous forests. However, other focuses, e.g. biosecurity, challenges and wildfire risk are strongly supported by the sector.

Designing forests - Mahi Tahi Whaihua

Research under this portfolio is to be directed towards both urban and rural forests and encompass ecosystem services, water quality, carbon budgets and biodiversity. Māori landowners, environmental afforestation companies, forestry industry representatives, and local body authorities are believed by Scion to be the non-government funded entities that will want access to its innovation facilities under this portfolio.

[61] Scion 2020 Annual Report 'Prosperity from trees-Mai i te ngahere oranga', September 2020, Page 26

Impact Area 2 – Forests to timber products

Trees to high-volume wood products

For this portfolio Scion's innovation facilities will be focused on researching mostly the radiata pine microbiome, biotechnology, breeding and propagation to increase productivity and resilience to abiotic and biotic threats; biosecurity to protect forests from new and existing pests and diseases; and forest management and environmental stewardship. In this portfolio the facilities also encompass harvesting and construction research. Key facilities will include breeding technology which will use genomic resources and seek to match the microbiome by genotype to each environment to achieve rapid and accurate breeding selection and deployment.

Scion sees future demand for its research and innovation facilities for this portfolio coming from the non-government entities such as the tree breeding companies, nurseries, forest growers, managers and owners, wood processors, the construction sector, farmers and exporters. An example of non-governmental backing for research in this portfolio is the 30 year study into sustaining forest productivity. This investigated soil nutrient levels and forest productivity through retention of forest harvest residues and the forest floor at low-fertility sites. This work was funded by New Zealand Forest Growers Levy Trust Inc, New Zealand, Forest Owners Association and New Zealand Farm Forestry Association with collaboration from New Zealand forestry companies and managers.[62]

Trees to high-value wood products

This portfolio and its innovation facilities cover both exotic and hardwood trees, forest production systems, high-value wood products and timber design and high-performance construction systems. To meet the expected demand from non-governmental entities this portfolio's research will explore speciality tree species and hybrids, genetics tailored to different environments, with the aim of providing valuable, durable and resilient products. Innovation facilities are also to be used to explore the resilience of the target trees to pests, disease, wilding, regenerative forest management and harvesting. The non-government funded entities that Scion expects to want to access its research and innovation facilities in this portfolio include wood processors, engineers, architects, designers and planners and wood product manufacturers.

An example of recent work in which private entities have funded research in the high-volume and high value products portfolios is the funding by the industry through the Forest Growers Research and the Forestry Growers Levy Trust of research into monitoring red needle cast from satellite imagery. This work involves calibrating the detection capability of satellite imagery with the disease's actual footprint. Another example is the work on SLAM technology (Simultaneous Location and Mapping. This technology is attached to an unmanned aerial vehicle (UAV) and flies through the forest under the canopy detecting tree stems and taking detailed measurements including location, diameter, height, stem volume, branching and stem defects, which helps to map the potential value of wood in the trees[63]. This work has been partially funded by non-government entities e.g. Forest Growers

[62] Scion 2021 Annual Report, September 2021, Page 23

[63] Scion 2020 Annual Report 'Prosperity from trees-Mai i te ngahere oranga', September 2020, Page 22

Research and Radiata Pine Breeding Company (RPBC)[64]. The RPBC has 15 Australasian shareholders representing organisations from across the forestry value chain including vertically integrated forestry companies, forest owners, forest management companies, and seed and planting stock producers. The RPBC has also funded Scion work on genomic selection which has involved genotyping 10,000 trees. Scion and the RPBC now have the data to assess how effective genomic selection will be for radiata pine which in 2020 was a first for a forest tree species. This has also involved improving the information available on the pedigree of New Zealand's radiata pine by comparing existing data with the tree genomes.[65]

Indigenous trees for distinct value wood products

Scion's research and innovation facilities in this portfolio will be seeking to meet demand for traceability, provenance, and seed ownership in indigenous forests, as well as developing speciality indigenous wood products. Hapū, whānau and iwi trusts, Māori owned nurseries, forestry and wood processing companies, non-Māori owned forestry and wood processing companies are expected to be the non-government entities who will be interested in accessing Scion's research and innovation facilities.

New value digital forests and wood sector

The research effort and innovations facilities in this portfolio will be directed at digitisation and automation of propagation in nurseries and tissue culture. These will also include digital support for next generation precision forestry practice using GPS and real-time enabled tracking of individual trees, automated planting, thinning and risk surveillance. Another technology approach will focus on the development of next generation growth models using artificial intelligence. Further work will be done on automated predictive harvesting to provide more value from the whole tree. Scion will focus on new technology to support traceability, transparency and transformation of forestry products, along with supply chain digitisation and real-time degradation monitoring in buildings.

Scion sees future demand for its research and innovation facilities in this portfolio from non-government entities such as data warehouses, early adopter growers and processors and technology companies.

The views of those we interviewed suggests that Scion's view of future demand from the sector is reasonable. We did not receive feedback that it was not focused on the right technological challenges in this area.

Impact Area 3 – Forests to biobased products

High-value biorefineries

This portfolio's research and innovation facilities will be focused on biorefineries which will aim to produce novel chemicals from radiata pine, indigenous and exotic plants and short-rotation and designer trees which will feed into a biomanufacturing industry. Products are expected to include

[64] See https://www.rpbc.co.nz/

[65] Scion 2020 Annual Report 'Prosperity from trees-Mai i te ngahere oranga', September 2020, Page 28 & 30

bioactive compounds and specialty/fine chemicals largely for export into global chemical supply chains. Scion sees the potential to transform today's pulp and paper mills into bioproducts mills and biorefineries.

The non-government funded entities that Scion expects to want to access its research and innovation facilities in this portfolio include international circular bioeconomy entities, forest growers, wood processors, iwi owned companies, fine chemical, pharma and nutraceutical companies.

Bioproducts and packaging

Scion foresees demand in this portfolio from onshore manufacture of bioproducts and biopolymers including plastic substitutes such as polyhydroxyalkanoates (PHAs). It's research and innovation facilities will investigate their ability to be composted. It also expects to focus on low-emission, non-toxic biobased coatings and adhesives, for use in interior, exterior and even food-based applications. Forest growers, wood processors, national and international brands, industry associations, composters, plastic manufacturers, iwi owned companies, innovative resource and biotech companies are believed by Scion to be the non-government funded entities that will want access to its innovation facilities under this portfolio.

Distributed and circular manufacturing

The objective of this portfolio is to convert underutilised, scattered or seasonal forest and/or agro-based biomass resources into intermediates and products. Scion sees development of the extruder as a chemical reactor to demonstrate turning slash to value-add biochemicals as an important step. Distributed manufacturing is another aspect of this portfolio. Scion believes that this has an advantage of being flexible so it can implement new and emerging technologies and develop a networked eco-industrial system that will go further than what it believes has achieved at Kawerau. Scion sees future demand for its research and innovation facilities for this portfolio coming from the non-government entities such as the forest growers, wood processors, processing and engineering companies, iwi owned companies and New Zealand primary sector.

Integrated bioenergy

Scion sees demand for this portfolio to deliver fuel and plastic substitution thereby lowering CO_2-e. Scion's innovation facilities will be focused on biojet, marine biofuels, solid industrial energy carrier and biohydrogen manufacturing and uptake. It expects to use radiata pine and other species where short rotation crops and waste streams are available. It believes that fuel companies and refineries, large end-users of energy, forest growers, wood processors, conversion technology providers, iwi and emerging companies will demand this research and access to its relevant innovation facilities. An example of non-government entities accessing Scion's skills and facilities to undertake work on this portfolio is the Ecogas venture. This involves transporting food waste from around the North Island to Reporoa where it is processed via anaerobic digestion and turned into biogas, heat, usable biogenic carbon dioxide and biofertiliser. This work has been funded by Ecogas, EcoStock Supplies Ltd and the Bioresource Processing Alliance[66].

[66] Scion 2020 Annual Report 'Prosperity from trees-Mai i te ngahere oranga', September 2020, Page 23

Interviewees had mixed views about Scion's view of future demand from the sector under this Impact area. There was concern about the risk of investing in areas where New Zealand does not have a strong competitive advantage or the level of funding of offshore research efforts. There was also concern about the economic fundamentals of some of the initiatives in this Impact Area.

13. Recommendations

The literature review found some useful guiding principles that have been introduced in other jurisdictions and could be applied to the New Zealand context.

The key takeaway from the stocktake of innovation facilities is that:

it is challenging to keep information relevant and up to date, which means some additional efforts need to be employed by innovation facilitates to improve visibility to external users

presenting this information in a user friendly and accessible manner, especially for those new to the New Zealand innovation landscape, is not easy and depends on the specific role an innovation facility has in the innovation ecosystem in a target sector (e.g., bespoke vs. standard innovation support)

understanding the linkages between facilities and expertise is sometimes muddled by marketing language.

Our key recommendations place more weight on the stakeholder engagement component of our analysis of access to innovation facilities:

Common across facilities were issues around accessing the required skills and expertise and how to best treat IP

Recommendations specific to each sector were centred around the speed and cost of the innovation process including potential gaps between pilot and scale up facilities

The key points for each recommendation below are in bold to help quickly direct the reader to the pertinent information in this section

Forecasting the demand for access to innovation facilities in each target sector is very difficult, and in some sectors (e.g., advanced manufacturing) almost impossible to implement

13.1 Common recommendations across the three sectors

Recognition of commercial pathways for career development at innovation facilities

Formal recognition of commercial pathways for career development at innovation facilities may help to increase the speed at which innovators are able to move through the innovation process and therefore increase capacity at innovation facilities. We heard that researchers at publicly funded innovation facilities are often driven by career development incentives that promote publications as a measurement of success which can lead to drawn out timelines for innovation projects. Instead of a "minimum-viable-product" approach to get the innovation to market as soon as possible, projects often end up being much larger and uncovering a greater depth of detail for the sake of publications that is not necessarily essential in the initial stages to the success of the innovation's market entry. This finding was common across the sectors we investigated.

If career development incentives for researchers are broader than just publications and capture commercial successes too (i.e. number of innovations gone through, success of the innovations on the market, etc.) then there may be a shift away from unnecessarily detailed/large projects that produce publications and a movement towards commercial projects that are driven by the industry timelines. In turn, a shift would likely increase the speed of the innovation process and free some capacity within innovation facilities for other innovators.

This is not easily directly influenced by the government since the roles for academics and researchers typically sit within universities or university-related facilities. Therefore, indirect incentive structures would be required that encourage universities or university-related facilities to implement commercially focused career development pathways alongside the traditional academic career development pathways. For example, a subsidy for facilities that offer commercially focused career development pathways may encourage some facilities to implement them.

Improved approach to handling IP

Management of IP across all the target sectors was raised as an issue by stakeholders.

Numerous users of innovation facilities within the forestry and wood processing sector reported feeling disincentivised with the way IP was handled and commented that Scion's approach tended to be inflexible and dogmatic. However, we note that Scion has made efforts to refresh its strategy with a greater focus on maximising the benefit to New Zealand, including its approach to IP. Scion's 'Overview of Intellectual Property Management at Scion', sets out its general approach to IP well**. It will be important for Scion to continue to communicate its approach to IP in all interactions with prospective innovators seeking to access Scion's research and innovation facilities.**

IP management within the food and beverage innovation facilities is inherently complex because public innovation facilities are expected to be able to produce very similar outcomes for different innovators, and therefore facilities cannot "unknow" what they already know and have developed from past innovation projects (e.g. formulations, processes, etc.). Some stakeholders saw this as a barrier to innovation and partnership with NZFIN, despite NZFIN trying its best to compartmentalise knowledge and data and block innovators from uncovering other innovators' IP. Issues around IP may be even more significant when considering contract manufacturers and private facilities since they do not have the same mandates as public innovation facilities and can easily glean IP. As a result, where possible stakeholders prefer to work with public innovation facilities. **It is important for public innovation facilities such as NZFIN to make the IP management strategies clear and readily available for innovators to limit concerns.**

Stakeholders within the advanced manufacturing sector saw IP mismanagement and past bad experiences with IP control at innovation facilities as a barrier to access and a cause for reluctance in engagement. **On both provider and accessor sides of facilities, stakeholders said there needs to be greater education about how to spot, control, and share IP to ensure IP management does not pose as a future barrier to access for innovation facilities.**

13.2 Food and beverage

Access price scaling to speed processes up

Access price scaling may be an effective way to speed processes up and ensure that facilities remain well-utilised, and innovators leave facilities to move on to the next stage of their innovation journey at the right time. In essence, this would mean that the cost to access innovation facilities would vary dependent on the size of the innovator accessing and increase over time as the innovator gets bigger and closer to commercialisation (i.e. scales up).

The purpose of this is so that facilities are easy to access for innovators at the start of their journey – the costs would be lowest relative to any other stage of the innovation process. Then, as innovators get bigger and take their innovations from bench-scale higher, the costs would increase to ensure that the innovator is incentivised to transition into the private sector as soon as possible. A higher cost burden (although not too high) would encourage innovators to focus on getting their innovation developed as soon as possible to minimise cost. As a result, innovators would be keen to transition to the private sector at the earliest viable position, which would free up capacity and allow other innovators to get access to facilities quicker.

This idea does not come without issues, however; one being the fine balance required when setting the scaling of access costs relative to different stages of the innovation process. If the costs are set too high relative to scale too early, then innovations may be prohibited from moving any further and essentially sit dormant or die. Despite this, there should be consideration of ways access price scaling can be implemented to incentivise speed of process.

Investment in new facilities, particularly scale-up

Investment into new facilities (including expertise), particularly for scale-up post-pilot, may help to increase capacity and ease the current constraints and excess demand innovation facilities are facing within the food and beverage sector. Investment may also benefit from being allocated to the plant-based food and beverage subsector too, as this seems to be where the greatest demand and lack of facilities exists.

Current facilities and their capacity and capabilities are not sufficient in supporting plant-based innovations, particularly due to path dependencies within the food and beverage sector and a historic focus on meat and dairy as leading New Zealand exports. The facilities available are not compatible with plant-based innovations for several reasons.[67] As an area of great current (and likely future)

[67] Facilities and equipment sometimes are configured to best suit more traditional dairy and meat processes that are not compatible for plant products with respect to risk management planning, temperatures, storage, etc.

interest, dedicated plant-based facilities would likely ease excess demand upon other currently used innovation facilities.

Separation of signposting and innovation work mandates of facilities

Multiple innovation facilities have the mandate of signposting and redirecting innovators to the appropriate facilities, which competes with their other mandate of providing services to innovators in two main ways:

- Takes away time and resource from the actual innovation process work.
- Creates incentive problem/conflict where signposter/redirector may be able to do the work, but may not be best placed to do so, however does the work anyway (i.e. using the position of power for personal interest).

There may be some advantages in considering some form of signposting and redirection from an independent body. It might operate these functions and more efficiently match innovators to facilities and capabilities. The likes of KTI in Ireland and KTN in the United Kingdom might be good examples of this. If the job of signposting and redirecting innovators to facilities sits outside the facilities themselves, or there is an additional independent source of advice, the facilities could have more time and resource to dedicate to the actual innovation process work. It may also better manage the incentive conflict problem. However, care needs to be taken to ensure that broader signposting and redirection initiatives, such as KTI and KTN, are kept up to date and relevant.

Focus on funding of cooperative foundational research

A focus on funding of cooperative foundational research by the government may lead to better innovation outcomes by removing competitive pressure amongst innovators to build foundational, basic science in new innovative areas. Stakeholders told us that multiple innovators are currently competing with limited resources on high-cost foundational research to try and get their innovation off the ground, which is inefficient since all are doing it at once at a relatively slow rate (since the costs are large and capacity and capability is lower than if they were all pooled together). If there were incentives and mechanisms from the government that promoted pooling of resources and collaboration on foundational, basic research and innovation in new innovative areas, then there may be greater innovative outcomes. This is because innovators would likely be able to:

- Make use of a nominally greater level of capacity and capability when pooled, rather than if all individually trying to do the same thing.
- Access facilities and services quicker with pooled capital, rather than having to wait longer to raise capital individually.
- Access facilities and services to a greater scale with pooled capital, as opposed to if they were doing it individually.

Some sort of explicit strategic government role in identifying and encouraging this sort of cooperative foundational research could be considered. This could link to efforts proposed by the Productivity Commission to strengthen and overcome barriers to collaboration among CRIs and other science system participants.[68] Such an initiative could lead to open-source IP at the end of the project which could result in innovators being able to access knowledge at a lower cost and speed up the innovation process – allowing innovators to build on the open-source knowledge to fill niches and different markets.

There are some intricacies to this, however. Private companies do not normally have the resource or capacity to be able to do this collaboration on their own, therefore a secretariat of some sort provided by the government would be necessary for coordinating and actioning the relationship to ensure outcomes are good. The Food Industry Enabling Technologies (FIET) is an extant collaborative commercially focused programme funded by MBIE that brings innovators and facilities together to build research that fills technology gaps within the New Zealand food and beverage sector. FIET may provide valuable learnings of how to operate similar collaborative arrangements that bring together innovators and facilities to conduct foundational, open-source research.

Future research and data collection around what happens when someone cannot access facilities

Data is not readily available around what happens when someone cannot access facilities, or the motivations for going to particular facilities within the ecosystem. For future planning, demand forecasting, and **understanding of the industry dynamics, future research and data collection is recommended.**

Even a simplistic collection of a few key metrics would provide useful insights into use and access patterns for innovations facilities as follows:

- Number of referrals made by facilities
- Where referrals are made to by facilities
- Number of innovators followed-through post initial contact
- Cancelations
- Exits, and for what reason.

These relatively simple metrics would help identify use and access trends and show where demand is highest and therefore capacity could be adjusted accordingly to share the load.

13.3 Advanced manufacturing

Socialisation of priority areas of innovation within advanced manufacturing

Stakeholders commented that it is unclear where the government priorities lie for innovation within advanced manufacturing, making it difficult for innovators to understand the likelihood of success of their funding proposals and their ability to secure funding for their innovation.

[68] New Zealand Productivity Commission (2021). New Zealand firms: Reaching for the frontier. Final report. Available at www.productivity.govt.nz/inquiries/frontier-firms/ Date: April 2021, Pages 106, 107 and Chapter 8.

The reason why this is important for innovators is because significant effort is required to prepare funding applications. When such funding applications are unsuccessful it can be both demoralising and a waste of already constrained resources, particularly for small innovative firms and/or start-ups.

Look to increase communication of the government priority areas for innovation in the advanced manufacturing sector. This will likely:

- Increase innovator awareness of the government priority areas for innovation support, dependent on technological, economic, and social trends (for example, if there is an increased emphasis on environmental impact, etc.).
- Allow innovators to plan better and more efficiently for funding applications.

Further research required within the advanced manufacturing sector

Stakeholders identified some areas for concern within the advanced manufacturing sector that could lead to future issues with access to innovation facilities and missed opportunities, if they are not investigated more thoroughly and addressed appropriately. There are three main areas for potential future exploration.

Firstly, looking at structural drivers of lack of capabilities within niche areas of advanced manufacturing in New Zealand. Is New Zealand well placed to be innovating in these areas (i.e. comparative advantage)? Is New Zealand developing human capital in these areas? If so, is the human capital being exported overseas? Why?

Secondly, exploration in more detail the need for scale-up facilities in the advanced manufacturing, to understand how widespread the perceived shortfall is, and whether there is anything the government can or should do to support innovators (e.g., processing tonnes of material in a demonstration plant, after the initial testing at lab scale).

Thirdly, cost of access to innovation facilities can be prohibitively high, motivating some innovators to look for solutions overseas. There can be various reasons for perceived high cost, such as the lack of economies of scale in operating innovation facilities in New Zealand, but also some potential duplication of equivalent facilities across various universities. Further research may need to be undertaken to **understand whether there is effectively an evidence of inefficient duplication of innovation facilities across universities, and if so, to determine if that creates a barrier for innovation in the advanced manufacturing sector in New Zealand**.

13.4 Forestry and wood processing

Access for new or smaller innovative firms or trusts

Larger established firms found accessing Scion's innovation facilities relatively easy as they generally had long term relationships with Scion and knew the Scion personnel well. This was not the case for smaller or newer firms. From Scion's perspective, the risk reward trade-off is strongly in favour of dealing with larger known entities with known credit histories.

New Zealand is likely to be missing out on innovation potential because of the difficulties smaller and newer firms have with accessing innovation research and facilities. To change this situation the

government could consider policy options that aim to change Scion's appetite to prioritise new or smaller firms.

This could include restructuring or repurposing existing funding options for innovative firms in the sector, such as the Strategic Science Investment Fund, Sustainable Food & Fibre Futures fund, or creating a new special purpose fund, that seek to select promising new forestry innovations that require further development by research facilities such as those at Scion or the University of Canterbury. One approach might be to review the incentives built into the funding contacts with the CRIs and assess the potential for incentivising and de-risking for Scion taking on small and/or first timer innovators. Some government funding support is likely to be needed to change the incentives within the existing institutional structure.

Distinct lack of scale up facilities, though provision of such facilities is difficult

Scion is pursuing an initiative to explore the potential for a bio-pilot plant. This would take the form of a pre-commercial production facility. It would use technology to produce small/medium level volumes products, mainly for the purpose of learning about the new technology or product. The idea is that a bio-pilot plant would de-risk this learning for innovators in the bio-products sector. However, such initiatives, as is evidenced by the Food Bowl, typically require significant infrastructure funding for often quite specialized equipment and multi-disciplinary personnel. This was the only area where the potential need for scale up facilities was flagged to us as part of our analysis of access to innovation facilities in the forestry sector.

The government should carefully consider the value of a bio-pilot plant for the forestry sector. This would require, as has been the case for such initiatives in the food and beverage sector, a detailed assessment of likely demand and for production of the product set such a plant would be capable of providing. Our analysis found some demand for such an approach from some interviewees. However, a specific study, focusing on this growing subsector of the forestry industry, would be required to properly investigate the options. A component of any study of the potential for a bio-pilot plant should be access pricing scaling as discussed above under the food and beverage recommendations.

Greater focus on industry problems

Our interviews highlighted that some in the sector believed Scion had not communicated very effectively with its stakeholders. However, this view appears to be based on Scion's approach in the past rather than its current approach in which it has prioritised its communication efforts. Bearing this in mind, **government should encourage Scion to continue and build on its strategy of improving its communications and interactions with the forestry sector and other stakeholders.** Scion's recent strategy appears to have been welcomed by the industry and is seeking to maximise the value added to New Zealand.

Better guidance and direction for new or smaller firms

Another option to assist new and smaller firms in accessing innovation facilities, by finding the right help with their innovation development ideas, would be to **create a position for a front person or relationships manager. Such a person could act to direct inquiries to the right people within the**

innovation facility. This is probably best done by each innovation facility rather than across innovation facilities because such a relationships manager must be fully au fait with personnel and capabilities of the facility. When such a role covers multiple innovation facilities, it is very challenging for that person to stay up to date with all the personnel and capabilities.

Such as position would require specific funding by the facility. To achieve this sort of policy intervention to assist access for new and smaller firms, **it might be necessary for government to make such a service an explicit part of its funding of innovation facilities**. This could help overcome research facilities understandable natural tendency to focus their research resources on lower risk, larger entities.

New or smaller firms could also be assisted in accessing innovation facilities if research and innovation facilities were to create access guidelines such as those discussed in the literature review. This would give innovators greater clarity about the basis of their access and help manage their expectations. It would be important that **such guidelines gave as much transparency as possible about the research entity's access policy – including how they regulate, grant, and support access to (potential) users from academia, business, industry, and public services as well as its costs and fees e.g. what sort of contribution to the financial sustainability of the facility is expected.**

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Appendix A Research and innovation support programmes and funds

Catalyst	Supports international research collaboration [Mission-led]
CoREs	Centres of Research Excellence focus on research in certain areas
Endeavour	Invests in research proposals for areas of future growth and critical need [Mission-led]
Health Research Council	Supports research that improves Kiwis health and well-being [Mission-led]
Marsden	For excellent fundamental research in science, engineering, maths, social sciences, and the humanities
National Science Challenges	Supports research projects that address pressing issues of national significance [Mission-led]
Partnered Research Fund	Supports greater connections between researchers and end-users
PBRF	The Performance-Based Research Fund supports research undertaken by universities
R&D Tax Incentives	A tax credit at a rate of 15% for eligible R&D activities undertaken in New Zealand
Regional Research Institutes	For stimulating leading edge, commercially focused research in areas of strengths of the respective regions
Strategic Science Investment Fund	Supports longer-term programmes of mission-led science and the platforms that enable them [Mission-led]
Sustainable Food & Fibre Futures	Supports problem-solving and innovation in food and fibre sectors by co-investing in initiatives that make a positive and lasting difference [Mission-led]
Vision Mātauranga	Supports development of Māori science research capability

Appendix B Food and beverage stocktake – provider facilities and equipment

Cawthron Institute

On-site facilities are equipped with:

- purpose designed wet-laboratories
- intensive algae culture facilities
- dry-laboratories
- a nursery building serviced by managed algae ponds, offices and amenities.
- Covering 20 hectares, the park hosts aquaculture industry firms, teaching labs operated by the Nelson Marlborough Institute of Technology, and Cawthron's aquaculture and biotechnology research group.

Cawthron's research centres and laboratories include:[69]

Research facility	About	Offering/research area
Cawthron Institute Culture Collection of Microalgae	A collection of marine and freshwater microalgae and cyanobacteria, both living and cryopreserved.	• Purchase of species and biological material
Cawthron Natural Compounds	Research facility for the production of bioactive natural products.	• Isolation of bioactive toxins to generate analytical standards or reagents. • Global commercial supply of microalgal toxin references and standards (i.e. those involved in paralytic shellfish poisoning) for commercial and academic customers.
Finfish Research Centre	Facility for science relating to fish stock management, breeding and husbandry to support growth of the NZ aquaculture industry (including data analysis, environmental monitoring, and controlled trials).	Unspecified.
National Algae Research Centre	Under construction. A hub of innovation to support establishment of NZ's seaweed industry. Stage 2 of the construction will enable Cawthron to	Key research areas: • Extraction of bioactive compounds • Climate change mitigation solutions

[69] https://www.cawthron.org.nz/our-research/our-resources/

	continue work in extracting bioactive compounds from microalgae.	• Seaweed ecology • Alternative proteins and sustainable food production • Farming systems development (including current *Asparagopsis armata* research)
PC2 Laboratory	Under construction. The facility will be equipped to undertaken pathogen-related research targeting known aquatic bacteria, viruses and parasites in New Zealand, and research into new aquaculture species.	• Pest/Pathogen identification • Pest threshold and prediction • Transmission studies • Species susceptibility trials • Treatment strategies • Potency studies • Salmon vaccine development • Breeding for disease resistance • Future proofing.
Taxonomy Laboratory	Provides marine and freshwater taxonomy services, including: • Taxonomy services for environmental assessment, consents and permits • Marine and estuarine fauna • Freshwater fauna • Molecular tools and analysis • Research • Industry training	• Specialist expertise in invertebrate taxonomy, particularly New Zealand marine benthic invertebrate macrofauna, phytoplankton and zooplankton • Extensive experience responding to environmental assessment, consents and permit requirements • Quality assurance work and peer reviews • Extensive laboratory capability including photo microscopy and large scale sample data entry • An extensive marine and freshwater species reference collection • Separate safe and secure facilities for storing samples

The Food Factory[70]

Facilities:

- Demonstration kitchen
- Four process rooms (each approximately 40m^2, with hot/cold water, compressed air and gas) as well as chiller, freezer and warehousing facilities.

Process rooms contain the following equipment:

[70] Privately owned and operated innovation facilitates.

- Colloid mill/grinder
- Dual tilting mixers (approx. 30l each) with scraper attachment
- Immersion stick blender
- Pneumatic filler machine
- Residential fridge & freezer
- Dishwasher/sterilizer
- Mobile gas hob
- Blue Seal 6 burner hob
- Convotherm steam oven
- Small Turbofan oven
- Large stock pot (approx. 40l)
- Oil press
- Commercial smoothie blender (x2)
- Benchtop scales
- Walk-in chiller
- Forklift and pallet jack

Pricing*

	Half-day or evening	**Full day and evening**	**Seven-day week**	**Four-week month**	**Notes**
Process room rate	-	$20 per hour (minimum eight hours)	$700	$2,600	Includes shared use of walk-in chiller and reasonable use of event space/demo kitchen at 50% discount
Chiller storage per shelf (approx. 1,400x800x800mm)	-	-	$10	$40	Preference is given to kitchen tenants
Warehouse space per sqm			$11.50		Preference is given to kitchen tenants
Warehouse storage per pallet			$6	$20	Preference is given to kitchen tenants
Event space/demo kitchen	$150	$250	-	-	

*Prices exclude GST. Refundable bond of $350 chargeable for all kitchen and demo-kitchen users.

Inclusions: use of all equipment if sufficiently trained, wifi, LPG, rubbish collection, compressed air, use of forklift (if licensed), use of pallet jacks, dishwasher use, 24/7 access, use of showers/toilets, communal kitchen, co-working space, cleaning of communal areas, storage space (per pallet cost additional), option to sell product in the Peanut Butter World shop (by agreement). Note: $350 bond required.

Food HQ

FoodHQ has access to the following facilities/capabilities:[71]

Design

- Generation of concept designs and aesthetics of food products and packaging
- 2D and 3D visual design, physical and mixed-reality prototyping of food products and packaging
- Visual and time-based communication design and branding
- Evaluating in-market cultural resonance of proposed food products and packaging
- Service Design in B2B supply chain and retail systems.

Consumer and sensory science

- Consumer and expert panels for evaluating acceptability and sensory characteristics of foods.
- Multiple controlled environment sensory booths
- Adaptable immersive space and mixed reality environments for understanding context specific responses
- Instrumental measures of physiological responses tapping into the consumer's emotional responses to food.

Omics for food

- Mass spectrometry and NMR metabolomics facilities for qualitative and quantitative metabolomics
- Advanced proteomics capability for detailed protein and peptide identification and structural characterisation
- Microbiome and metagenomics expertise for understanding microbial function and gene regulation
- World-leading researchers with published track records in the application of 'omics technologies to food

Food microstructure

- X-ray diffraction
- NMR (including metabolomics and imaging)
- A wide range of microscopy techniques and image analysis, including transmitted light and fluorescence (widefield and confocal), atomic force, Raman, and electron (TEM and SEM/EDS).

[71] https://www.foodhq.com/facilities

Companion animal nutrition

- Assessing the impact of complete foods, supplements, or individual ingredients on animal wellbeing across their lifespans, including palatability trials utilising real-time intake and feeding behaviour recordings.
- Assessing the effects of nutrition on disease, immunity, and microflora.

Pilot-scale food processing

- state of the art equipment for the thermal treatment of liquid and solid products
- spray dryers of varying sizes
- a microbrewery
- aseptic liquid packaging
- workshop and testing capability to develop and validate new technologies for new or niche applications.

New Zealand Food Innovation Network

FoodBowl

Processing capabilities:

- retort
- extrusion
- drying
- extraction including super critical CO_2
- high-pressure processing
- separation
- fermentation
- powder processing
- packing
- beverages and liquids
- separation
- blending
- UHT and pasteurisation
- aseptic filling.

FoodPilot

Capabilities and equipment:

- Spray dryers: five of from simple 100 g/hr to multi-stage 30 kg/hr
- Evaporators: falling film (180 L/h feed); rising film (~50 L batch) and scraped surface
- Other dryers: fluid beds (static + VFB), tray, roller, freeze (18 kg/day), atmospheric freeze (12 kg/day)

- Powder handling: sifter, magnet grid, gas-packing, X-ray, coater-agglomerator, dry blenders
- Continuous heat treatment: four UHT plants (50 – 300 L/h), direct and indirect; two pasteurisers
- Batch heat treatment: Steriflo rotary hot water retort; stationary steam retort; Megge microwave retort.
- Batch pressure treatment: Uhde-Multivac 3L HPP
- Cooker-processors: 300 L Optimix, Blentech lay-down cooker; Limitec vertical cooker; steam pans
- Homogenisation: seven two-stage valve homogenisers, bench to free-standing, two are aseptic; Stansted UHPH
- Agitated tanks: multiple including turbine, hydrofoil, ribbon, Cowles, cage-rotor and scraped surface
- Size reduction: disintegrators, bowl choppers, colloid mills, dry mills
- Extrusion: Clextral BC21 with range of feeders, dies and post-processing
- Packing and filling: Can seamer, aseptic bag filler; Xenos aseptic bottle cold filler, laminar flow cabinet, range of vacuum & atmospheric heat sealers.
- Beverages: Screw press, basket press, pulper-finisher, carbonator, fillers, fermenters for wine, beer, kombucha, kefir etc
- Filtration: RO, UF, MF all cross-flow; range of in-line dead-end filters; plate & frame, columns
- Centrifuges: Disc-bowl (three of 20 – 100 L/hr including self-de-sludger), decanter (two-phase)
- Red meat: boning room with rail, tables, blast freezer, conditioning rooms, chillers, freezers
- Small goods: brine-injector, vacuum-tumbler, smoker, bowl chopper, sausage filler, slicer, curing rooms, patty-former
- Bakery: planetary mixers, dough sheeter, ovens
- Dairy: cheese-making, yogurt fermenters, cream cheese ice-cream machine

FoodSouth

Capabilities and equipment:

- Spray dryer: GEA Niro SD-4 with25kg/hr water evaporation capacity
- Other dryers: belt dryer 80kg/hr, and spiral flash dryer due for commissioning Feb 2022.
- Extrusion: Clextral BC34 twin screw, Vemag Robot 500
- Heat treatment and homogenisation: homogenisation, pasteurisation and direct/indirect Hipex UHT (30-100L/hr)
- A range of vessels and jacketed pans 50-400L capacity, agitated, heating and chilling
- Packing and filling: aseptic bag filler; vacuum sealer, tray sealer, auger filling machine, liquid piston filler, viscous piston filler 10-280mL single head, powder filler
- Filtration: range of membrane filtration including RO and NF

- Mixing: planetary mixer, spiral mixer, SS rotary mixer & clamps, stainless steel mincer, Stephan mixer UM24, Drum Mixer
- Combi oven and Irinox blast chiller freezer
- Decanter and clarifier.

University of Auckland – Food and Bioproduct Processing

Research areas:

- Non-thermal and thermal processing of food, including pulsed electric field (PEF), high pressure processing (HPP) and UV treatment
  - PEF unit
  - Patented Pressure Assisted Thermal Sterilisation Technology
  - Microwave and ohmic heating
  - 0.3L high-pressure process (HPP) machine
  - 2L HPP machine
- Food microstructure
  - Use of equipment from the Research Centre for Surface and Materials Science (RCSMS)
- Refrigeration and food transportation
- Fouling mitigation and surface engineering (e.g. removal of fouling in milking machines, and removal of proteins from wine)
- Simulation and control (e.g. control measurement strategies for milk dryer viscosity).
  - Electrical resistance tomography (ERT)

Collaborations with local organisations:

- Fonterra
- Heinz Watties Australasia
- Flo-Dry Engineering
- Plant and Food Research
- AgriGenesis Bioscience Ltd
- Keam Holden Associate Ltd
- Kiwi Fruit Company/Argon
- Sanford Ltd
- Fast food chains such as McDonalds
- Small companies like the Juice Factory in Auckland

University of Otago – Department of Food Science / Product Development Research Centre

Expertise offered:

* Product and process development
    * New product development.
    * Product reformulation.
    * Shelf life extension.
    * Product and process optimising.
    * Formulations to meet specific nutritional compositions e.g. infant formulas, animal feeds.
    * Development of foods to meet specific dietary requirements e.g. gluten-free or to meet specific diets e.g. Paleo.
    * Reformulation to reduce salt, sugar and/or fat.
* Shelf life
    * Shelf life calculations
    * Shelf life studies
    * Shelf life extension
    * Product, process and packaging development to achieve specific shelf life objectives
* Troubleshooting and general consultancy
    * Ingredient advice
    * Specification writing
    * Reviews of scientific and technical literature
* Food safety and food spoilage
    * Design/modification of product formulations prevent/limit food spoilage and prevent growth of pathogens.
    * Design/modification of manufacturing processes to prevent/limit food spoilage and prevent growth of pathogens.
    * Design of food safety (including HACCP) and quality systems to prevent/limit food spoilage and prevent food safety problems.
    * Validation of production processes to demonstrate product safety.
    * Tracking the source of pathogen and food spoilage problems in your factory.
    * Evaluation of sanitation protocols, provide sanitation recommendations and protocols.
    * High throughput screening for antimicrobial activity.
    * Bioadhesion / biofilm formation and removal.
* Product quality
    * Including access to analytical equipment
* Sensory science
    * Descriptive analysis (trained panel characterisation of food attributes)
    * Consumer acceptability and liking
    * Category appraisal
    * Preference mapping

  - Linking consumer preference to analytical measures and or product characteristics
  - Consumer focus groups
  - Consumer product perceptions (consumer perceptions of product quality)
  - Temporal changes in perception during consumption
  - Time intensity measures
  - In vivo flavour measurement during eating
- Analytical services
  - Analysis of chemical constituents of the food product
    - Flavour analysis and profiling
    - Off flavour and taint identification
    - Lipid analysis and profiling
    - Antioxidant activity
    - pH, Water activity
  - Bespoke analyses by HPLC; UV and fluorescence spectroscopy; GC-MS and NMR
  - Colour analysis
  - Particle size analysis and zeta potential (particle charge)
  - Textural analysis
    - Viscosity
    - Texture profile
    - Gel strength
    - Meat tenderness

Facilities:[72]

- Pulsed electric field (PEF) – DIL El-Crack PEF processor
- Proton Transfer Mass Spectrometry (PTR-MS) (Ionicon, Austria)
- Gas Chromatography Suite
  - Gas Chromatography Olfactometry (GC-O)
  - Gas Chromatography Mass Spectrometer (GC-MS)
  - Two dimensional GC/MS + Olfactometer
  - three other GC instruments with flame ionisation detection (FID) and autosamplers for liquid injection and static headspace sampling
- High performance liquid chromatography (HPLC)
  - two Agilent 1200 series modular HPLC instruments
  - Detectors include 3D-DAD (diode array) for UV-Visible detection, ELSD (Evaporative Light Scattering) and Fluorescence
  - Bioinert 1260 Infinity Bioinery Quaternary LC
  - Varian 9010 HPLC with UV-Vis spectrophotometer and fraction collection
  - Fast Protein Liquid Chromatography (FPLC)

[72] https://www.otago.ac.nz/food-science/research/otago077785.html

- Brabender – twin screw extruder
- In-house microbiological lab space
- In-house microbrewing capability

University of Waikato – School of Science

Waikato Mass Spectrometry Facility

The Waikato Mass Spectrometry Facility is part of the School of Science and School of Engineering at the University of Waikato in Hamilton (https://www.mass-spec.co.nz/home).

The facility operates and maintains the school's range of high-performance mass spectrometers. The instrumentation supports research activities within the schools and a range of services are available to external institutions and industrial clients.

Appendix C Advanced manufacturing stocktake – provider facilities and equipment

AUT Biodesign Lab

Research areas:

- Autonomic nervous system monitoring and modification
- Augmented breathing
- Biomedical sensor signal processing and integration
- Brain signal processing, integration, and artificial intelligence
- Metabolic health monitoring and modification
- Musculoskeletal biomechanics and biomechatronics
- Technology and human-microbe interactions

Partner organisations:

- NASA Ames Research Centre
- Cre8 Technologies Ltd.
- Zero Cast Ltd.
- Aō Air
- Nelson Artificial Intelligence Institute
- University of Auckland Cardiovascular Autonomic Research Cluster
- University of Auckland Translational Cardio-Respiratory Research Laboratory
- Aalborg University Faculty of Medicine
- DEC International
- Globex Engineering Ltd
- AUT Knowledge Engineering & Discovery Research Institute
- AUT Health & Rehabilitation Research Institute
- AUT National Institute for Stroke and Applied Neuroscience
- AUT Traumatic Brain Injury Network
- AUT Good Health Design
- AUT Institute of Biomedical Technologies
- AUT Sports Performance Research Institute New Zealand
- AUT Human Potential Centre
- AUT Sentience Lab
- AUT Ventures Ltd

Auckland Bioengineering Institute

Equipment[73]

- 3D printers
    - Ultimaker 2+ (x2)
    - Formlabs Form 2 SLA 3D printer
- Cutting and measuring
    - CNC Lathe: DMG MORI CX Alfa 500
    - ProtoMAX Waterjet
    - FaroArm platinum series
    - Trotec Speedy 300 cutter and engraver
- Testing
    - Instron 5800 series
    - Biaxial testing instrument (unique equipment)
- Milling
    - Five axes CNC milling machine: DMG MORI DMU 50
    - DMU 35M CNC milling machine
- Microscopy
    - Nikon inverted microscope TE-2000E
- Other equipment
    - Nakanishi 50,000 rpm high speed spindle for small part machining
    - Microtap tapping machine
    - Hafco Manual Mill and Lathe
    - Ultrasonic bath
- Electronics
    - Manufacture of printed circuit boards: LPKF ProtoMat S42
    - Microscopes
    - ESD mats
    - Hot air, ability to do board pre-heating
    - SMT oven
    - Desoldering station
- Gait analysis treadmill – Kistler Gaitway Instrumented Treadmill System
- Work-loop calorimeter (developed by ABI for measuring properties of realistically contracting individual heart muscles)
- MicroCT instruments:
    - Bruker SkyScan 1272 desktop MicroCT

[73] https://www.auckland.ac.nz/en/abi/about-the-institute/lab-workshop-facilities.html

- SkyScan 1172 desktop MicroCT

Pricing[74]

CNC machines: $100 per hour with a technician.

Workshop and other equipment is $65 per hour with a technician.

MicroCT scanner and X-ray microscope

- MicroCT instrument and operator
- UoA and external institution $85
- Commercial and industry $150
- UoA and external institution $50

Workstation hire

- UoA and external institution $20
- Commercial and industry $50

Additional services requiring facility staff

Image reconstruction, 3D visualization, movies, analysis and reports

- UoA and external institutions $60
- Commercial and industry $95

Charges are hourly with a minimum of one hour. Charges for instruments and workstation are on time used and not booked time. ABI and Med Tech CoRE projects are subsidised.

Centre for Advanced Composite Materials (CACM)

Facilities[75]

Physical testing equipment

- Imatek fully instrumented drop weight impact tester IM10-20
- Electro-mechanical universal testing machines
  - Instron 1186
  - Instron 1185
  - Instron 5567
- Servo-hydraulic universal testing machine: Instron 8802
- Environmental chamber for use within Instron 1185/1186
- Weighing balances
  - Mettler Toledo AG204

[74] https://www.auckland.ac.nz/en/abi/about-the-institute/lab-workshop-facilities/hire-equipment.html
[75] https://www.cacm.auckland.ac.nz/en/cacm/cacm-facilities.html

    - Mettler Toledo PG8001
    - Mettler Toledo SB16001
    - Sartorius SARLP12000S
- Moisture content balance
    - Sartorius MA35 (ASTM D789)
- Differential Scanning Calorimeter: TA Instruments Q1000
- Rheometer: Parr-Physica UDS200
- Environmental chamber: Contherm CAT180RHS
- Cone calorimeter
- High-speed camera
- Viscometer
- Charpy impact testing

Manufacturing equipment

- Extruders
    - Brabender DSE 20 computer-controlled co-rotating twin screw extruder suitable for polymer blending
    - Cincinnati Milacron TC-35 computer-controlled co-rotating twin screw extruder
- Injection moulder
    - BOY 50A
- Heated presses
    - A range, from 10-100 ton.
- Resin infusion and RTM light facilities
    - Stereophotogrammetry system for dynamic thickness measurements during flexible mould processes.
    - Range of moulds and peripheral equipment, including vacuum pumps and instrumentation.
- Rigid tool RTM and CRTM facilities
    - a range of rigid-tool RTM and CRTM moulds, which can be utilised in various presses and testing machines. These include planar and non-planar geometries with a range of monitoring instrumentation.
    - TEkScan – distributed pressure monitoring
- Ultrasonic welder
    - Rinco MP2022 Ultrasonice Press Machine
- Rotational moulder
    - Custom built "rock and roll" type lab-scale rotomoulding oven.
- Sample cutting (clicking) press
    - Repeatable sample cutting (with numerous custom blades)
- Drying ovens and dehumidifiers
    - Elecfurn FC 100/40/100 oven

    - Squaroid Duo-Vac oven
    - Napco 5861 Vacuum oven
    - Moretto Dry-Air Dehumidifiers
- Other equipment
    - Rollformer
    - Compounders
    - Ultrasonic bath
    - Retsch ultra-centrifugal mill
    - Laboratory Ash Furnace (ASTM D2584, D5630)
    - Melt Flow Index (MFI), Melt Flow Rate (MFR), (ASTM D1238 (Procedure A), D3364)
    - Accelerated Weathering by QUV (ASTM D4329, D4587)
    - Dynamic Mechanical Analysis (DMA) (ASTM D4065, D4440, D5279)
    - Compositional Analysis by Thermogravimetric Analysis (TGA) (ASTM E1131)
    - Differential Scanning Calorimeter (DSC) (ASTM D3418, E1356)
    - Capillary Rheometry, Thermal Stability (ASTM D3835)
    - Thermal Conductivity (not Thermal Resistance)
    - Xenon-Arc Exposure of Plastics Intended for Indoor or Outdoor Applications (ASTM D2565, D4459)
    - Colour Analysis (ASTM D6290)
    - Oxygen Permeation and Leak Detection

Centre for Materials Science and Technology

Capabilities and equipment:

- Controlled environmental chamber and conditioned space
- Tactile, visual and other sensory facilities
- Instrumentation for characterising fibres, yarns, fabrics and clothing, for example:
    - thermal and moisture properties of materials (such as a Sweating Guarded Hotplate; water vapour and air permeability testers)
    - equipment for artificially ageing fibres, yarns, and fabrics
- Instrumentation for fibre/material development, for example:
    - 3D printer
    - extruder
    - electrospinner

Ferrier Institute

The Ferrier Institute has the following capabilities and equipment:[76]

- Nuclear magnetic resonance (NMR) spectroscopy
    - Two Bruker 500 mHz spectrometers
    - One Bruker MHz NMR spectrometer
- Mass spectrometry
    - Agilent 6130 LCMS with an Agilent 1260 HPLC front end
    - Agilent GC and Agilent GCMS
- High-performance liquid chromatography (HPLC)
    - Four stand-alone Agilent HPLC systems with diode array (DAD), refractive index (RI) and charged aerosol detection (CAD).
    - Dionex high-performance anion exchange chromatography system with pulsed amperometric detection (HPAE-PAD).
    - Waters HPLC system interfaced with a multi-angle laser light scattering detector (MALLS).
    - HPLC detection systems: charged aerosol detection (CAD), evaporative light scattering (ELS), fluorescence, and UV detection, including photodiode array (PD).
    - General Electric ÄKTA protein purification system.
    - Laboratory viscometry measurement apparatus.
- Synthesis equipment
    - Two flow microreactors
    - ThalesNano H-Cube® flow hydrogenation reactor
    - 8 Büchi Pure C-815 Flash automated flash chromatography systems with UV and ELSD detection
    - Polarimeter
    - Microwave reactor
    - Reaction calorimetry apparatus
    - Pressure hydrogenation facilities

In collaboration with GlycoSyn, laboratory and pilot-scale chemical processing facilities are available. Equipment includes:

- glass reactors from 500 mL to 2500 L
- evaporation equipment from 1 to 100 L
- freeze-dryers
- calorimetry for process scale-up.

[76] https://www.wgtn.ac.nz/ferrier/services/facilities

MacDiarmid Institute

Innovation facilities are listed on the webpage www.macdiarmid.ac.nz/about-us/facilities.

Equipment/instruments available	Description available on the webpage
1 Tesla vibrationing sample magnetometer (VSM)	For magnetic field loops (+/- 1 Tesla) and temperature dependent magnetisation from 20 to 310 K
Analytical ultracentrifugation	Size and shape determination of nanoparticles, such as proteins, quantum dots etc, through sedimentation in solutions (usually aqueous, but can be anything)
Ar ion mill	For physical milling/patterning of thin film structures into patterned devices using a beam of Ar ions.
Atomic force microscope	Nanosurf FlexAFM atomic force microscope (AFM). Contact and tapping modes, including conductive, magnetic and piezoresponse.
Atomic force microscopy and magnetic force microscopy	Can do atomic force microscopy, magnetic force microscopy and piezoelectric force microscopy
Biological applications laboratory	For fabrication of microfluidic and Lab-on-a-Chip devices using photo- and soft-lithography, micro-milling, and their characterization and application to live cell and microorganism culture in combination with fluorescence and confocal microscopy
CD micro-spectrometer	Custom-built spectrometer system with intense broadband white light (UV-near-IR), alternating circular polarisation, high-NA microscope objectives, and spectrometer with CCD and PMT detectors for absorbance, fluorescence, Raman measurements of optical activity.
Cleanroom fabrication facility	Equipment suite for the fabrication of microelectronic devices. Includes photolithography evaporation, sputter coating, oxygen plasma etching and electrical testing
Cluster deposition system	This purpose-built system provides a capability to deposit nanoparticles of controlled sizes and to measure the electrical properties of devices fabricated using the nanoparticles as building blocks.
Dynamic microfluidics laboratory	High-speed cameras, lighting, lenses etc. optimised for visualising droplet-scale microfluidics experiments
Electrochemical instrumentation	Extensive suite of electrochemical instrumentation to perform variety of electrochemical analyses

Electrochemistry facility	A wide range of potentiostats capable of common electrochemical techniques like cyclic voltammetry and impedance spectroscopy. Current ranges from 100 femtoamps to 10 Amp. Also rotating disc and ring-disc electrodes, electrochemical quartz crystal microbalance, photoelectrochemical set-up and online gas chromatography (coupled to electrochemical cells)
Electron beam annealing	Vacuum annealing system using a medium energy (30 keV) electron beam to heat inorganic samples up to 1,200° C
Emulsion formation and characterisation facility	Mechanical mixers and ultrasound probe for preparing colloid dispersions and static light scattering, bulk rotational rheometers, interfacial rheolometer, microscopy and interfacial tensiometry equipment for characterising them
Field emission measurement – vacuum chamber	Vacuum chamber to undertake field emission measurements
Gas absorption analyzer	For measuring the uptake of gases by porous materials, for example to determine the BET surface area or their affinity for various guests
Gas separation analyzer	For measuring the performance of membranes or porous materials in separating gas mixtures
Hall probe	Four-point probe to measure conductivity, carrier concentration and mobility
Inert atmosphere glovebox	For synthesis and manipulation of materials under an inert atmosphere
Ion beam analysis facility – 3 MV Van de Graaf accelerator and beamlines	3 MV Van de Graaf accelerator and beamlines to undertake a range of ion beam analyses including: Rutherford backscattering spectrometry (RBS), particle induced X-ray emission (PIXE), nuclear reaction analysis (NRA), elastic recoil detection (ERD). Provides elemental and structural characterization.
Ion beam sputter deposition	Thin film deposition equipment using 20 kV accelerated inert gas beam to sputter atom from a target onto samples to be coated.
Ion implantation facility	Undertake ion implantation with acceleration voltages ranging from 1 to 60 keV in 1 cm2 size sample.
Low and high field NMR facility	Facility for material characterisation using NMR spectroscopy, diffusometry and imaging.
Low-temperature vacuum cryostat	Vacuum cryostat with 20x20 cm sample stage, currently set up for thermopower and resistivity measurements down to 5 K.

MOKE (magneto-optical Kerr effect) microscope	For imaging magnetic domains of materials and measuring magnetisation loops with magnetic fields both in-plane and out-of-plane using polarised light at ambient and cryogenic conditions.
Nanopipetting equipment	Equipment for making, positioning, and transducing through nanopipettes. Can be adapted for functions such as scanning ion conductance microscopy, resistive pulse sensing, and soft particle mechanical measurements.
Optical lithography laboratory	The combination of a basic mask aligner, spinner, evaporator etc provide capability for simple lithographic processing with resolution down to about 1 μm.
Optical tweezers	Optical tweezers use focussed laser beams to manipulate microscopic particles and measure forces at the nm and pN scales, for example colloidal interactions and single molecule stretching.
Raman laboratory (VUW)	Raman spectrometers: Raman microscopes with multiple laser excitations, time-resolved (ms) and scanning/mapping capabilities. Combined absorption/extinction UV/Vis spectrophotometer for measuring turbid samples.
Raman microscope	For using Raman microscopy to examine distribution and variations in composition over an area, with micron to sub micron resolution.
Raman spectroscopy (custom-built)	Raman spectroscopy facility including low-frequency, spectroelectrochemical, and high pressure measurements.
Raman spectroscopy systems	For recording the vibrations spectrum of system using a wide range of Raman spectroscopy techniques, including Resonance Raman, low-frequency Raman, time-resolved Raman and non-resonant Raman spectroscopies
Scanning tunnelling microscope/atomic force microscope	Omicron variable temperature STM/AFM provides a capability for atomic resolution imaging and scanning tunnelling spectroscopy of nanostructures and surfaces.
Six-target magnetron thin film sputtering system	For depositing thin films and multilayers by magnetron sputtering in ultra-high vacuum - optimised for spintronic structures such as GMR or TMR junctions.
Surface plasmon resonance (SPR)	Custom-built surface plasmon resonance setup. Can also be combined with Raman spectroscopy.
Transient absorption and emission	For measuring the excited state dynamics on the nano to micro second timescales via transient absorption and phosphorescence spectroscopies.

Ultrafast optical spectroscopy facility	For measuring excited state dynamics on ultrafast timescales via transient absorption, fluorescence, stimulated Raman, and time-domain terahertz spectroscopies.

Polymer Biointerface Centre

Capabilities:[77]

Bioelectronics

Creating electronic communication bridges between devices and biological matter (cells, tissues, organs, bodies). Examples involve:

- Development of new organic conducting materials with biomimetic properties
- Interfacing miniaturized human tissue and organ models to study
- Important biological and physiological responses conformal electronic devices that measure and sense

Sensors

Developing disposable and non-invasive sensors and biosensors to monitor important biological and physiological parameters.

These may be point-of-care and in-field (bio)sensors, and implantable or integrated (bio)sensors with the bioelectronic devices for long-term monitoring of physiological states.

Membranes and Packaging

Creating multifunctional membranes that can specifically capture and release biological targets to concentrate these for analysis and diagnostics; that can act as antimicrobial and antioxidant interfaces.

Tissues interfaces

Development of novel materials for interfacing with biological matter and understanding phenomena and surface properties that underpin material-biomolecule interactions.

Examples include creating smart materials that control cellular, tissues and organs' behaviour.

Research Centre for Surface and Materials Science (RCMS)

From here[78]

- Scanning Electron Microscopy (SEM)
- Environmental Scanning Electron Microscopy (ESEM)

[77] https://www.auckland.ac.nz/en/science/our-research/research-institutes-and-centres/polymer-biointerface-centre/our-research.html
[78] https://www.auckland.ac.nz/en/engineering/our-research/discover/research-areas-and-facilities/rcsms.html

- Energy Dispersive Spectroscopy (EDS)
- Electron Backscatter Diffraction (EBSD)
- X-Ray Photoelectron Spectroscopy (XPS)
- Ultraviolet Photoelectron Spectroscopy (UPS)
- Atomic Force Microscope (AFM)
- High resolution metal coater
- Transmission Electron Microscope (TEM)

University of Canterbury

University of Canterbury's website lists the following laboratories and facilities:[79]

Capabilities	Equipment
Metalwork	• Lathes, milling machines, 60-watt and 130-watt laser cutter/engraver, battery and hand tools. • MARS 1/3 sheet non-metal • Kreon laser scanner
Woodwork	• A table saw, thicknessor, bandsaws, drill presses, wood lathe and various sanding machinery, battery and hand tools.

Advance Prototyping	• 3D printers:
	  ○ UP 3D printers
	  ○ Stratasys Connex Objet 350 Polyjet printer
	  ○ Stratasys Elite ABS FDM printer
	  ○ 5 x TierTime UP Box FDM printers
	  ○ 4 x TierTime Up Mini 2 FDM printers
	• 3D scanners:
	  ○ Artec Eva hand held scanner
	  ○ Artec Spider hand held scanner
	  ○ 3D Systems Sense hand held scanner

Electronics	• Power-supplied meters, soldering equipment and electrical tools
	• High voltage testing:
	  ○ Impulse generator - inverted Marx multi-stage unit
	  ○ HVac testing transformer
	  ○ Tesla coil (150 kV)
	  ○ Sphere gaps
	  ○ Capacitative divider
	  ○ Resistive divider
	• RF and microwave spectrum analysers
	• A microwave vector network analyser
	• Microwave power meter

[79] https://www.canterbury.ac.nz/engineering/schools/engineering/

	• RF and microwave signal sources and pulse generators
Plastic work	• Thermoformer • Strip heaters • Hot wires
Formulation	• Magnetic and overhead stirrers, a centrifuge, a pH meter, an oven, microscopes • Silverson Homogenizer • 3D Bioprinter • UV-vis spectrophotometer • Skin analyser.
Virtual reality, games, AR	• Room-scale VR setup using Vive and a 2080Ti, a selection of game consoles: 2 x Nintendo Switch, 2 x PS4 Pro (One with PlayStation VR), 2 x XBox One X and a library of games for evaluation. • Oculus Rifts, HTC Vive Focus, Oculus Go, HP Windows MR headsets, Xbox Controllers, PlayStation Controllers, audio recorders, cameras and headphones.
Acoustics	• Hearing protection test facilities (fixtures and facility compliant with AS/NZS 1270) • Ceiling flanking noise facility compliant with ASTM E1414 • Tyre-road noise measuring system • Traffic noise barrier attenuation measurement system • Low noise wind tunnel for aero acoustic measurements • Facility for assessing human response to noise • Duct noise test facility • Sound intensity systems • Environmental noise measurement and analysis facilities • Fan noise test facility compliant with the relevant BS EN standard

Robotics	• Universal Robots 7-axis UR5 robot
	• Epson 4-axis G10 SCARA robot with camera system
	• Also available is a suite of dSPACE rapid control system prototyping equipment. This includes the following modular boards:
	  ○ DS1006 processors
	  ○ DS2002 multi-channel A/D
	  ○ DS2101 multi-channel D/A
	  ○ DS3002 incremental encoder interface
	  ○ DS1104 R&D controller boards

Electron microscopy	• JEOL JSM IT-300 variable pressure scanning electron microscope
	  ○ Oxford Aztec SDD energy dispersive x-ray analysis system
	  ○ Aztec/HKL Electron Backscattered Detector (EBSD) system
	  ○ Aztec Large area mapping and Feature software
	  ○ Forescatter and backscatter electron detectors
	• Philips CM200 high resolution analytical transmission electron microscope
	  ○ Single and double tilt holders

	○ Oxford INCA energy dispersive x-ray analysis system ○ Gatan digital camera • JEOL JSM 7000F field emission, high resolution scanning electron microscope ○ JEOL energy dispersive x-ray analysis system ○ Backscatter electron detector ○ Infrared chamber camera ○ Gatan Cathodoluminescence detector • Philips CM120 transmission electron microscope (available from late 2017) ○ Single and double tilt holders • Support equipment ○ Gatan Pips Precision ion Polishing System ○ Gatan Model 691 dimple grinder ○ Fischione twin jet electro polishing unit ○ Emitech K975X Coater (gold sputter and carbon evaporative coating) ○ Scanner for TEM negatives ○ Darkroom facilities
Aerodynamics, hydrodynamics and PIV	• Aeronautical closed-circuit wind tunnel - 1.25m x 0.91m with a 2.5m long working section, max. air speed 55m/s (200kph). • Atmospheric boundary-layer wind tunnel - 1.23m x 1.26m with a 13.1m long working section, max. air speed 26m/s (94kph) - with low noise working section. • Six- and three- axis force balances • Various pressure measurement systems • Dantec miniCTA hotwire anemometry system with associated software (single and 3-axis probes) • Smoke flow visualisation equipment. • Various air-flow anemometers and manometers. • StereoPIV measurement equipment with a 120mJ double pulse Nd:YAG laser, 2x TSI 4MP cameras, 2x Dantec 2MP cameras. • Photron SA5 high speed camera. • UAV rotor thrust rig.
Materials and metallurgy	• Electron microscopy ○ JEOL 7000F Field Emission Scanning electron microscope with Gatan cathodoluminescence detector and JEOL JED-2300 Energy Dispersive X-ray analysis system ○ JEOL JSM IT-300 variable pressure scanning electron microscope with Oxford AZtecHKL EBSD system and Oxford Aztec SDD energy dispersive x-ray analysis system ○ Philips CM200 high resolution analytical transmission electron microscope with Oxford Inca energy dispersive x-ray analysis system, Gatan CCD camera and Gatan double-tilt holder ○ Philips CM120 Transmission Electron Microscope with Gatan CCD camera and Gatan double-tilt holder • Optical Microscopy

- Leica DM-IRM inverted metallurgical research microscope with digital image capture systems
- Olympus reflected light optical microscopes with image capture systems
- Olympus stereo optical microscope

- Materials preparation
  - Gatan Precision ion polishing system (PIPS)
  - Fischione dual jet electropolisher
  - Diamond saws for composite and metallic sample preparation
  - Buehler Automated mounting press
  - Buehler and Leco Automated polishing systems
  - Carbon coaters
  - Gold sputter coaters
- Materials processing and treatment
  - 10 kW Vacuum/Ar atmosphere induction furnace for casting high purity aluminium and magnesium alloys
  - 40 kW induction furnace for steel production
  - Gas-fired furnace for Al melting
  - Various radiant furnaces from 200-2000°C for heat treatment and sintering
  - Oil and salt quench baths
  - Laboratory cold and hot rolling mill
  - Pulsed Chemical Vapour Deposition Unit for thin films
  - Gibitre Instruments hot press for polymer and composites manufacture with vacuum frame
  - Set-up for wet lay-up and vacuum bag processing of composite laminates
  - Twin screw extruder for polymer processing/compounding (owned by CAPE)
- Mechanical testing
  - MTS Criterion Model C43.104, Tensile/compression load frame (100 N, 500 N and 10 kN load cells, non-contact laser strain measurement, bio-chamber for fluid immersion testing, temperature chamber (< 250°C), testing of soft matter, polymers and fibres)
  - MTS858, Tensile/compression load frame (2.5 kN and 10 kN load cells, pneumatic pressure controlled grips, testing of foams, polymers and composites)
  - MTS810, Tensile/compression load frame (25 kN and 100 kN load cells, extensometers (8, 12, 25, 50 mm), testing of high strength metals and composites)
  - Satec heavy duty tensile-compression testing rig with 1 MN load cell
  - Fatigue testing (bench of 6 reverse bending rigs, hot Wohler type rig)
  - Assorted hardness/microhardness testing machines (metals, polymers)
  - Charpy Impact Tester for metals and advanced composites
  - Thermomechanical testing

	○ TA Instruments, Dynamic Mechanical Analyzer (DMA) Q800 with humidity controller for viscoelasticity (damping) measurements of polymers and composites ○ Perkin Elmer Differential Scanning Calorimeter (DSC) DSC8500 with robotic autosampler (automatic loading/unloading of up to 43 samples), heating rates up to 300°C/min ○ TA Instruments, Thermogravametric Analyser (TGA)(CHEM Dept) ○ Netzsch TMA 402 F1 Thermal Mechanical Analysis instrument capable of both elevated (up to 1500 oC) and sub-ambient temperature testing ○ Zwick / Roell HIT 50P Impact Tester capable of Charpy Testing Polymer and Composite materials • Environmental testing ○ BioLogic VSP potentiostat system (5-channel chassis, 3 channels/modules available), EC-Lab software, EIS analyser, 1 flat cell, Pt counter electrode, saturated calomel reference electrode, CO2 incubator for pH-controlled corrosion testing in simulated body fluids/proteins, etc. ○ Microprobe electrochemical analysis system (custom-made) for microstructure-level corrosion measurements ○ Hydrogen evolution measurement set-up (custom-made) for corrosion of Mg alloys ○ Microscal light fastness tester
Thermodynamics	• Compact electrode boiler operating at up to 1.7 MPa as a steam source for a throttling calorimeter used to determine the dryness fraction of steam. • Two self-contained refrigeration/heat pump experimental test facilities • Two self-contained air motor experimental test facilities • Apparatus to investigate forced convective heat transfer for air flow through a heated tube • Capstone Micro Turbine 30kW Diesel generator set with full monitoring software. Connected with an Exhaust Heat Exchanger for experimental purposes. • Whispergen Micro CHP, 1kW Electrical and 6kW Hot Water with performance instrumentation.
Advanced energy and materials	• 2 Fume hoods for chemical preparation and sample mamking • Lage vacuum glove box • Pulsed chemical vapour deposition (PCVD) reactor
Metrology	• Talysurf surface roughness measuring machine
Nanofabrication	• Two-Photon Polimerization 3D Printer (Nanoscribe Photonic Professional GT2) • Electron Beam Lithography (Raith 150) • Deep Reactive Ion Etching (PlasmaPro 100 Cobra) • Optical Microscopy (Olympus BX30 with digital image capture) • Atomic Force Microscope (Digital Instruments Dimension 3100) • Plasma Ashing (Tergeo plasma cleaner) • Optical Lithography (Suss MA-6)

	• Nanoimprint Lithography (EVG) • Interference Lithography • Spin-coating (Laurell WS-650 and Headway PWM32-PS-R790) • Thin-Film Deposition (Edwards AUTO 500, Temescal FC-1800 and Mist CVD) • Semiconductor Device Characterisation (HP 4155A Parameter Analyser) • Optical Profilometer (Filmetrics Profilm3D) • Wire Bonding (Kulicke & Soffa 4500) • Micromilling (CNC Mini- Mill/GX)
Biological applications	• Two-Photon Polimerization 3D Printer (Nanoscribe Photonic Professional GT2) • Electron Beam Lithography (Raith 150) • Deep Reactive Ion Etching (PlasmaPro 100 Cobra) • Optical Microscopy (Olympus BX30 with digital image capture) • Atomic Force Microscope (Digital Instruments Dimension 3100) • Plasma Ashing (Tergeo plasma cleaner) • Optical Lithography (Suss MA-6) • Nanoimprint Lithography (EVG) • Interference Lithography • Spin-coating (Laurell WS-650 and Headway PWM32-PS-R790) • Thin-Film Deposition (Edwards AUTO 500, Temescal FC-1800 and Mist CVD) • Semiconductor Device Characterisation (HP 4155A Parameter Analyser) • Optical Profilometer (Filmetrics Profilm3D) • Wire Bonding (Kulicke & Soffa 4500) • Micromilling (CNC Mini- Mill/GX)
Optics	• Optical table • Spatial light modulator • Bimorph mirror • Various optical assemblies, including both gas and semiconductor 3B and 3R class lasers • Several high-speed CCD and CMOS cameras

Robinson Research Institute

Note: unclear whether this is from MacDiarmid or is onsite at Robinson.[80]

- Physical property measurement system (PPMS) and SQUID magnetometer
- six-target Kurt J Lesker CMS-18 thin film sputtering system
- FEI Quanta 450 and FEI Nova NanoSEM 450 scanning electron microscopes
- a carbon coater, metal coater and a Gatan Precision Ion Polishing System (PIPS)

[80] https://www.wgtn.ac.nz/robinson/research/facilities

- HTS Wire Characterisation (custom-built)
- Chirascan circular dichroism spectrometer

Titanium Industry Development Association (TiDA)

TiDA's equipment includes:[81]

- Large vacuum furnace, capable of operating at up to 1350 Centigrade, and pressures as low as 10-3Pa (working volume 1,000 x 500 x 450mm). It is used for:
    - Sintering (heating metal or ceramic powders to form a solid body)
    - Titanium nitriding (increasing surface hardness through reacting titanium with nitrogen at high temperatures).
    - Stress relieving (used for titanium produced by SLM 3D printing and other materials).
- ZEISS EVO MA25 Scanning Electron Microscope (SEM) (largest specimen capability in NZ)
- Buehler Inverted Metallographic Microscope
- WAAM robot and part manipulator – allows parts to be made from scratch and co-ordinates motion with the two computer controller machines.
- EOS270 Selective Laser Melting (SLM) 3D printer:
    - Titanium, stainless steel and other materials
    - Powder bed/surface-melt system
    - Build volume 250x250x215mm
    - 2 to 20 mm3/s build rate – material dependent
    - Direct CAD model to part – no tooling needed
- 200 Tonne Press – primarily used to conduct press consolidation on various powder metallurgy materials
- Buehler Hv Micro Hardness Tester
- Wilson Macro Hardness Tester (on long-term loan from South Auckland Forging Ltd)
- Tensile/Compressive Tester – Instron 5985
- Fritsch Laser Particle Sizer
- Fatigue Testing Machine (Wohler)

University of Waikato – School of Engineering

WaiCAMM

WaiCAMM has the following capabilities and equipment:

- Polymers and composite research
    - Natural fibre composites (including hemp, harakeke and wood)

[81] https://tida.co.nz/our-equipment/

- High performance composites
- 3D-> 4D printing
- Nanocellulose
- Self-healing composites
- Fracture mechanics and failure prediction
- Protein derived polymers
- Magnetorheological materials

- Metals and advanced alloys research
  - Powder metallurgy
  - Advanced solidification
  - Additive manufacturing (3D printing)
  - Low cost high performance titanium alloys
  - High entropy alloys
  - Antibacterial biomedical alloys
  - Architectured materials
  - Advanced heat sink materials
- Inspection and characterisation research
  - Non-destructive evaluation
  - Experimental mechanics and stress assessment
  - Through life monitoring
  - Fracture mechanics and failure prediction

WaiRAS

Equipment:

- Prototype 3D printing – SLA 3D printer (large build area 600mm x 600mm x 400mm)
- Carbon fibre 3D printing
- General purpose 3D printing: many small FDM machines
- Innovative FDM filaments from biomaterials
- 3D metal printing (titanium and stainless steel; in the process of being acquired)

Appendix D Forestry and wood processing stocktake

Scion

It has a range of unique innovation infrastructure including:

- National Herbarium (indigenous tree species and seed), (Nationally Significant Collection/Database).
- Soil database (plantation forestry).
- Research sites (permanent forestry sample plots, Puruki Research Forest, Tree archive, Durability trials).
- Pilot Scale Mechanical pulping plant.
- Testing facilities (box, biodegradation, disintegration).
- Super critical fluid extraction facility.
- National Forestry Library.
- Xylarium (A collection of authenticated wood specimens)
- GMO Field Trial and glasshouse facilities.
- Biosecurity - Insect rearing and containment facility. [82]

Scion has set out its priorities for future direction and investment as including: [83]

- Plant species – breeding and propagating.
- Whole plant physiology, biotic forest dynamics, remote sensing technologies including artificial intelligence, silviculture, forest resilience, novel and functional biomaterials, manufacturing processes for biomaterials.
- Redirect capability in wood science, modification and timber engineering and water processing and recycling.

The University of Canterbury – College of Engineering, School of Forestry, and the Wood Technology Research Centre

The University of Canterbury has teaching and research facilities and a Wood Technology precinct, which contains a timber drying and preservation unit, a pulp and paper room, and a general workshop. It has access to publicly and privately owned exotic plantations and native forest areas which are used for teaching and research.[84]

[82] See Value of Crown Research Institutes in Aotearoa New Zealand's science system today. 'A Report for Science New Zealand', 7 September 2021, Page 164.
[83] See Value of Crown Research Institutes in Aotearoa New Zealand's science system today. 'A Report for Science New Zealand', 7 September 2021, Page 165
[84] Source: https://www.canterbury.ac.nz/engineering/schools/forestry/

The School of Forestry has research facilities which include its laboratories for:

- Wood science[85]
- Forest engineering[86]
- Teaching
- Forest health[87]; and
- Wood technology[88]

It also has field stations for teaching and research at Cass, Harihari, Kaikoura and Westport. The School of Forestry breaks its research focus into four clusters which cover:

- sustainable land management,
- forest engineering,
- understanding reduced forest variability; and
- forestry as a business.

The School's focus on sustainable land management encompasses, biodiversity, restoration ecology, pest management, continuous cover forestry focused on beech in particular, dryland forestry as well as forest site assessments. Its forestry engineering work has covered biomass/bioenergy, machine and system operational efficiency and forestry roading and environmental impacts e.g. erosion and sedimentation. The School's third research cluster which seeks to understand reduced forest variability is investigating wood quality, breeding, silviculture and modelling of growth and climate change. The business focused cluster covers economic and market analysis, business performance, valuation, carbon forestry, land management planning and land use change and ecosystem services.

Wood Technology Research Centre

The Wood Technology Research Centre was set up in 1996. Its objective was to exchange information among staff engaged in wood-related research, facilitate the shared use of research facilities, enhance research programmes and promote technology transfer to end users. Its staff are from the Departments of Chemical and Process Engineering, Forestry, Civil and Natural Resources Engineering, Electrical and Computer Engineering, Mechanical Engineering, Chemistry, and Biological Sciences. It organises workshops and seminars and co-ordinates visits of wood scientists and technologists to the University. The Centre also has links and collaborative projects with both international and national research institutes. Its members conduct Government and industry funded research projects.[89]

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[85] This laboratory is used for wood analytics. Instruments include an IR Spectrometer, Raman Spectrometer and an accelerated solvent extractor.

[86] This laboratory is used for forest engineering teaching, research and tutorials

[87] This laboratory is used for entomology and ecology teaching and research.

[88] Equipment in this laboratory includes saws, planers etc., a high temperature kiln, preservation cylinder, incising machine, pulp and paper equipment, grinder, pellet press and an 'Instron' strength testing machine.

[89] Source : https://www.canterbury.ac.nz/engineering/schools/forestry/research/woodtech/

Appendix E Evidence of stakeholder experiences

Those accessing innovation facilities – advanced manufacturing

Firstly, the analysis looks to those who would require access to innovation facilities.

The ability to access facilities is variable, as are the capabilities facilities provide

Interviewees made it clear there is variability in the way they can access innovation facilities, although the ability to access likely depends on the level to which innovation facilities' offerings meet the niche of interviewees needs.

> No issues with access. Generally ok to find the people – NZ is a village, so can find someone quickly, and there is quite a lot of innovation going on in pockets, e.g. in Auckland and Christchurch.

> We have access to everything we need – got enough and [university] doesn't get in our way. Can get on with our work. Starting to engage with [innovation facility] engineers to help us develop and apply technical services they have.

> Technically, [innovation facility] can help us. Was extremely expensive so went to another local company in Auckland – said same thing e.g. needs these specifications – very similar outcome. Very prohibitive cost [for facilities].

> Still actively working with lots of them [innovation facilities]. Have a good relationship with **Plant and Food** but taken 10 years to get to this point.

> Often disappointed with the external help we have been given. Internalised some of it and got better results because of it.

When accessible, the innovation facilities generally provide good equipment and expertise that would otherwise be unobtainable or usable for innovative firms.

> Why we use them – otherwise would be as significant investment to do what they are doing. In addition to facilities, comes with technical expertise. Dealing with rock stars.

> Never had an incident where said I have some equipment, but you can't use it. People are so giving and will help if they can.

> Gracefield is great, has all you might need to use.

> Gracefield as an ecosystem, but almost like one thing. All the people who work there all understand each other's capabilities and equipment. Deal with them all as one.

> More recently, ramped up engagement with NZ product accelerator – umbrella organisation of different research institutes. Super valuable for finding people and resources + capability.
>
> At [university department] we have everything we need.
>
> Able to work with Callaghan because they had a [specific equipment]. Right size and machine to do it. Also talked to Massey but fell out of contact. Didn't have the bandwidth to support that kind of work.
>
> Some benefits – use some of the facilities at Callaghan routinely. At the moment, not big enough to justify buying that equipment. Occasionally is justified to go on electron microscope at the institute too.

But there are some things that the innovation facilities do not provide (often in niche areas), meaning not all firms find value in using the facilities.

> Not too involved with Callaghan. We are the only ones in NZ, if not the world, doing this type of business. We don't supply innovation facilities to anyone but ourselves. Never used Callaghan facilities in the past. Never had the intention to use public innovation facilities. With what we do, we need things to work in a certain way.
>
> Can't hire a good electronic engineer and do a 6-month project – we need more people.
>
> As a textile manufacturer, if we want to analyse and laminate, we have to go elsewhere (sometimes offshore). Cannot get these things done in NZ. Most of our R&D has lately been offshore. Quite often, in the hands of our clients. They are finding out what our product does and in turn owning the IP. Things we should know but haven't had the opportunity to do so.
>
> Some of the expertise exists in NZ, but in terms of consultants you could go to, we haven't found anyone yet that we think is going to be able to assist us in that area. There are situations where we want more help, but cannot find anyone who is suitable. Looking for someone who can help without having to put more effort in than they are putting in. Doesn't make sense otherwise, we may as well do all of it.

One interviewee said they internalised their R&D processes because of previous IP issues when dealing with innovation facilities.

> Do the R&D here. Have our own customer test lab on site, involves making composites on site. Lesson learned [from IP leakage]; built our own R&D, bring research in house. Keeping it all internal. Significant leakage possible – we can control in house otherwise.

Some said the innovation facilities are good for bench-side concepts, but often lack the scale-up and pilot facilities to convert the proven concepts into commercialised products.

> Most unis and Callaghan have furnaces but would stop at lab scale. Ours are pilot up to manufacturing (bigger).
>
> We are not sure whether 3D printing has scale here.

Come here [to Callaghan], work with experts, get the results you need to globalise your product. Partners to scale up ideas. Don't know if there are many examples where that has actually happened.

Don't have too much experience, we have looked elsewhere. One of our challenges is how to scale.

Will have to scale once done pilot programme. Best option would either be moving to someone's steel mill site or build our own demonstration plant. Would be expensive move for the company but would be at a stage where we are processing tonnes of material. Lab facilities [at the university] will not be sufficient for that.

Pilot facilities is big gap in this country. The equipment we need to scale-up (especially in food and beverage); can design in a beaker and extract, but hard to find a place to commercialise and get big. When you finally get to the scale-up phase, the pricing is way too high for a govt. subsidised thing. $300/hr for a scientist to work on a product you already know how to make it exorbitant. Don't actually need the scientist, but it is policy. Food and Plant needed 3 scientists @ $300/hr to work on it, which we know how to do easily. Eventually started employing people that they can train to do the work but took a lot of time. At the Food Bowl, wouldn't be able to do that.

Speed of access and process can be slow

The overwhelming majority of interviewees said that the biggest downfall of public innovation facilities is the time it takes to engage and follow through with contracts and innovation work. As a result, many internalise their R&D processes to match their own innovation cycles and timeframes.

Biggest thing with dealing with public sector, is we are a small entrepreneurial company want things done tomorrow. Pace of public sector so much slower. Can go weeks or months without hearing from people.

Single hardest thing is urgency with third parties.

From the start of talking to [the university], was 7 months before we got finalised and signed. If we were waiting that long outside of university to get work, would be killer to us. Being already at [the university] helped to keep working even without the lease agreement. Grateful for all the support, but slow organisation – clashes with innovation. Not particularly efficient in writing the agreements up, not something they do often within the university. We got it done, and I think primarily because of our existing relationship. If we were a garage start-up instead that didn't have an approved lab, I think it would be a lot harder to strike a deal where we could hire lab space. Not impossible, but a lot harder.

We have found in past that some external R&D done is not fast. As a small company, want to be nimble and adapt to market forces quickly. If we see an opportunity, want to be able to leap and get to market quickly. Traditional R&D cycle longer and slower than compatible for us. For that reason, keep a lot internal.

Project was taking so long though that it was hard to continue to support it without knowing when the end goal was going to come. 18 months on it – carpet got pulled out

> from under when [work not done]. 1 field test done on site, large number of issues. No real path toward commercial viability.
>
> [Callaghan] are not that useful though. Lots of talking, not enough doing.
>
> When we have gone to some parties like Callaghan, they turn what we want into something really large and do a lot of reports. We just want to get something done – spend a lot of time and don't get a lot of result. Could be their incentives.

Incentives and mandates of innovation facilities do not always align with innovation firms

The incentives and mandates of innovation facilities do not always align with innovation firms. Largely, innovation firms are looking for fast solutions to get their products to market as quick as possible to ensure a strong foothold in the market. Innovation facilities (particularly those led by academics) often clash with this by trying to flesh out problems and innovations into wider research opportunities.

> With the product accelerator – work with them on a product. If you needed a part of testing, you go to a specific partner to get their expertise. If you went to University of Auckland, suddenly UniServices would swoop in and try and take the project over. Turn a 6-week project into 3 PhD projects.
>
> Personal view that there are certain types of personalities keen to do research. When they come up with an interesting problem, want to understand it all and drill down on it when it may not necessarily be what the fastest way forward it (not matching to the briefs). Some idiosyncrasies in the system, lots of work to understand those rather than deliver something that worked, quickly.
>
> Unfortunately, quite narrow and the question we were asking led to a big windy pathway, rather than direct. Wanted to do research project, build optimal [product]. Academic approach to R&D; rather than good enough, go for best. If trying to get to the market quickly, then want good enough. Not necessarily the best straight away. Got the impression they were trying to make it into more than it needed be. Not sure how their renumeration works, but at UC it is on PBRF system. Renumerated on how many papers and what tier of journal it is published in. Academics looking through the lens of can I get a paper out of it? Can I turn this into a larger project?
>
> Decided to get in touch with Callaghan – able to use almost the same equipment but without the commute times and the inconvenience. For Vic, it is a teaching institution – no incentive to work with businesses. Paid for the machine use, but people who work there is not in their job description. Callaghan has a mandate, however.

Not only that, but there is no requirement for the facility to find a solution that will work and take the product to market.

> Biggest challenge is paying a lot of money to a research institute, but at the end of the day, they don't have to make something work. They will spend the money trying to answer some questions. That is the mandate. They will not work until they solve it, whereas with us, the job basically hinges on making things work. Company only makes money when things work. Universities don't necessarily have to garner a result.

In one instance, the innovation facility was using a company name and their associated technologies and capabilities to win funding but then were not collaborating with the company on the proposed work.

> Access to labs etc. was hard – never really getting what it is you wanted. The motivation seemed to be to use our name as a commercial partner to get funding to pursue their own interests. Because we were so active, a lot of people throwing endeavour and MBIE grants at us, using [specific technology] to get funding. Once the funding came, never heard from them again. We are a lot choosier now. Wrote an internal policy – if you want to use our name, we will take 30% of the funds. Stopped a lot of the enquiries. Introduced in about 2016. Never really what we wanted out of the project, driven by the scientists.

Others mentioned that the mandate to publish findings clashes with IP protection, making them reluctant to engage with innovation facilities.

> One challenge with what we do (a bit with the thesis), publishing research is not necessarily what we want. Don't want commercial secrets to get out.

Cost of access to facilities and expertise is variable

Cost of access to innovation facilities is variable and largely dependent on the area of specialisation. In some cases, the equipment required is highly specialised and not provided readily by innovation facilities, for whatever reason that may be. As a result, costs are high because of lack of economies of scale and the irregularity of service.

> What would cost $100,000 in NZ, would cost $10,000 in China. Even with Callaghan help, would be a quarter the price in China. Also used Callaghan – had professors and engineers part of government organisation – scoped making this [product] – was phenomenally expensive, quoted well over $100,000 for design work. Got whole thing done in China for $5,000, as was based on something already there.
>
> I think labour costs and expertise. Expertise in NZ are very good engineers, they can make it, but problem is they're making it from scratch. No company here that's made Wi-Fi and camera products that have experts in place. If this in place, would be a quarter of the price.

Some see the costs as reasonable, and have no problem paying them. Again, this is likely where the facilities used are more general and enjoy economies of scale in operation.

> Usually, a bit cheaper than private sector – modest discount there. Usually paying also for all the capability and infrastructure around it. Just means they can do more things and get more input on the problems you are trying to solve. If you want something outside of core scope in private, they will bring consultants etc. in. Don't have the breadth a bigger research institute has.
>
> [Costs are] specific to domain you are in. For us in organic chemistry, minerals etc. it is fine. More cost-effective than private by 10-20%. Competitive though, not selling themselves short. Get what you pay for. Happy with the way it is priced. Could probably live with them being higher, but happy they are not.

One interviewee raised importantly how double-ups of key equipment leads to higher use costs and inefficiencies in access that may turn some people away from using innovation facilities.

> Charges are transparent and fair I think, but model compared to overseas, can understand why access to innovation facilities in NZ is difficult. In the UK is so much better. Almost every single university and facility in NZ have the same instruments. Million-dollar machines, all have the same ones and multiple versions, supplied by the govt. In the UK, our uni did not have machines that Vic have. Govt. picked 5 universities in UK (of about 50) to buy machinery, and then set up a fund so that everyone from every other university has subsidised access to the machines (i.e. travel costs paid for, etc.). Too many toys, not efficiently used, and therefore overcharged.

Nature of the relationship is often informal, but some have good commercial focuses

Generally, the nature of the relationship between the innovation facility and the innovator is informal and reliant on existing relationships or being in the right place at the right time.

> Good relationship with MacDiarmid – first org we will call if we try to find something. Got 4 or 5 associates or former investigators from there. Already have personal network, then we go there if there is something we are looking for.

> Previously one of the pieces of equipment I had access to through Vic. Was based on informal relationship, however. When the person left Vic, we lost access to the piece of equipment. Very quickly got the impression we were inconveniencing them.

In a few cases, however, there are examples of innovation facilities that have good commercial focuses and systematic processes for engagement.

> Lincoln [university] surprising – went because of fertiliser technology. Commercially focused, really good to deal with. Pleasantly surprising.

> Vic university – good, seems to be particularly well-trod path of industry engagement and doing R&D. Contracting process straightforward and commercial. May just be that we are dealing with research teams inclined that way, but good experience.

> Callaghan probably more industry focused though. With no charge did the initial investigation. Looked at some literature etc., this is what we propose.

> Good relationship with them, can get rapid access to their microscopes. Is good if we can go into a discussion with a customer that we have gone right down to the detail and why the technology is improving their material. Mostly 1-way collaboration – we have our technicians inducted and trained on their equipment, so we don't need to pay their staff time. Staff from our place go in and use the equipment, only pay for the equipment time. For all equipment, inducted into labs and on the equipment. Making streamlined as possible, charge outs for labour are extremely high.

> Auckland UniServices is good because they have some commercial sense and are willing to foster the relationship. As with Callaghan. Everyone else chasing research money. Unique in the NZ system, however.

Whatever does happen, mostly does not happen systematically. There is a missing link between academia and commercialisation.

> Yes, from my observation. Is significant opportunity here – happening at Auckland University and Cloud 9 research institute. Not that there's nothing happening, just not common.

> Interaction with crown research institutes was a learning curve, took a lot to learn who to engage with and how to engage with, and where. When started, knew the customer manager, but over time our team has built up and is about 70% technical focused. 6 PhDs on staff. A lot with their own research networks. First approach when I need to find an expert, go to principal scientists. Use him for networking to find the people who know the experts. Knowledge base expanded as business expanded, can tap in overseas and around the country to different networks.

Funding can be hard to secure, although where found, is enabling

Some interviewees said it is often hard to secure funding for innovation, particularly if the innovation is not novel.

> Had to be so blue sky and novel for the Endeavour and MBIE funds. Virtually unfeasible. Not what we wanted to work on. Wanted to do things where we could see a potential commercial outcome in 1-2 years. The funding however incentivised dragging things out.

> Got a bit sick of the funding. Trying to build know-how of our tech in NZ. A lot of the competitors overseas are deeply connected with universities or Crown Research Institutes. Get R&D teams for cheap. Only need to use a specific machine once a week – not going to buy one. Can use the university or CRI tools and equipment.

Others that did manage to secure funding saw it as an enabler for innovation activity that otherwise would not be able to happen.

> R&D probably wouldn't have been done if the funding wasn't available. Made it cheap to finance for us.

> Definitely use the govt. grant money. Ways of getting money for research development. Helps to support the activities. This is why we can have more staff, get into some projects that require us to spend money on materials we otherwise wouldn't have got access to.

Awareness of facilities, capabilities, and alternatives is generally not good

In general, awareness of facilities, capabilities, and alternatives is not good. There are a select few cases where people are aware, but there are many factors that can play into this including personal networks, experiences, and past employment roles.

> Works well for some reason. All know enough about each other to know who to talk to – fair idea of what equipment is around and about, even if it is not in the organisation. Healthy ecosystem.

> The alternatives were there – proposing a different kind of [specific equipment] at Massey, but from research I have done either could be viable.

Others have stated how hard it is to be aware of facilities and particularly if alternatives exist. In a lot of cases New Zealand is small enough that facilities and alternatives do not exist on shore for more niche innovation areas.

> Auckland is for some reason fragmented. Complex, big, lots of institutions. Some cross talk between UoA and AUT, but mainly discipline experts that talk to each other because of academic relations.

> There are alternatives to Callaghan, they are just not experienced in camera technology.

> Not really sure. Used to be a number of things before Callaghan which we could turn to. Seems to have all been umbrella'd now. Lots of companies that would help develop if going commercial. No others off the top of my head.

One of the most significant consequences of this poor awareness is a double-up of resources across different centres. This likely makes the innovation process inefficient and could drive costs to the user higher too. Not only is visibility poor externally, it is also poor internally and between departments and innovation facilities.

> A lot wasted resource in skills and equipment that would be handy for manufacturers if they could use it at universities and CRIs. Most equipment we use, even interdepartmentally they don't share at these places. Quite often see the same piece of equipment in engineering, medical, and chemistry. Will never talk or share the equipment. For an outsider, typically hard to access and don't have the other options.

> Isn't a holistic view of all the resources available for research. Some way to pull this together or even if people don't want to share their toys too openly, have a query system where you can send out RFP or something – can you get in touch and give us a quote

Not only is visibility poor externally, it is also poor internally and between departments and innovation facilities.

> Research institute challenges though – don't always know what they have. No interfaculty connections. Need to connect dots to get something done – people unaware of related work between chemistry and chemical engineering for example. Operate in silos by individual faculty. Don't necessarily play nicely with each other because there is a bit of thieving of ideas etc. Going a couple of levels down, people will not even know each other's names sometimes. Process to find the right people, and then also to connect them.

Those providing innovation facilities – Advanced Manufacturing

There are some similarities in the themes uncovered between those accessing and those providing innovation facilities.

Differences in mandates across facilities results in different relationships and behaviours

There are clear differences in the mandates of different innovation facilities that results in different relationship types and behaviours. One of the most consistently raised differences is the incentive structure for academics within universities and CRIs, as research outcomes (publications etc.) often drive promotions and career development, while work with industry and non-publishable projects do not.

> Autonomy jealously guarded in the schools by academics – being able to do what they want.
>
> Would generally do partnership research project if there is interest from our [university] researchers. Usually the case.
>
> Reward systems of universities are based on PBRF (performance-based research fund) and publications. Not surprising that a lot will not engage elsewhere. One of the main obstacles for collaboration.
>
> Commitments around students and their own research, connecting to funding for Endeavour programmes, etc. In terms of innovation space, getting access to some of those things can be a bit of a barrier. Even we [as a crown research institute] find ourselves trying to access equipment in universities and we cannot get it. Incentives are different in universities. Primary job is teaching, fundamental driver [of activity]. While they do help businesses, it is on the side where they can and where it aligns with their own expertise.

The dual mandate of university or university-associated facilities also likely plays into the timeliness/speed of the process. Innovators often want the shortest path to market, while researchers want publications that take a lot longer to produce.

> Being clear around organisational KPIs and mandates is important. Smaller businesses going through personal networks and connecting with universities and CRIs – [the] ability to respond [in a timely fashion is] not there.

The dual mandate of university or university-associated facilities and the desire to publish research may feed into a reluctance of innovators to engage with universities.

> A lot of manufacturers don't want to go to universities for help… I organised a meeting for them to meet university people; set it up on campus, told they didn't want to come on campus.

Other groups/facilities that do not have research outcomes and objectives/KPIs may be able to better align with innovators and develop successful relationships.

> Strength of groups like [ours] – our mandate to collaborate means we can bring groups together to cross these silos which academia really struggles to do. [Work in] themes though – not typical industry vertical [silos]. But span in a way that underpin things like sustainability. E.g. new forms of energy – can be batteries, electrical conduction, can be

> photovoltaics which capture energy. Bit of an industry silo, but not narrow or homogenous.

In one example we heard that a research commissioning model was employed at a facility that focused primarily on multinationals and selling research overseas.

> Primarily, driven by large multinationals purchasing research off us. Get a bit of it from nutraceutical space (tech side of food), people coming to get their seaweed (e.g.) made better. Traditionally, the direct industry engagement work taken up by central part of university office. Changing because need a different approach to generate those sorts of connections. Cannot just sit and wait, need to be active and get out and talk to people.

Some interviewees commented that there is a conscious effort to try and pivot facilities mandates and goals to deliver a business outcome, rather than just research outcomes.

> One of the key things is being conscious that the research needs to pivot to deliver a business outcome. Not a project for the sake of research. We need to change to do this.

> Growing mandate to move toward making the facilities as available and open to NZ innovators as we can. Important thing we should be doing. As a business, started to think about how [university] wasn't that great at commercialisation. Lots of opportunity to be better. 18-24 months of work on it – university recognise the value we add now. Formally going through consultation process now so there is an agency for commissioned research.

However, this will likely continue to be hard to do unless reward systems in universities and university-associated facilities recognise industry collaboration as a valuable output of time and research effort (not just publications).

Capacity is constrained at facilities, especially because of dual mandates

Some facilities are referred work or are keen to be involved but do not have the capacity to do it. Sometimes this is because facilities have dual mandates (particularly universities or university-associated facilities) that forces a trade-off between innovation work and teaching and research responsibilities.

> This is the big problem – you will see things on paper, but it doesn't work in practice, because we get references from NZPA saying someone wants a problem solved, etc, and we have technicians that can do that, but our technicians/students are there to do our research, lectures and teaching – nothing has been factored in to take on these industrial jobs. There's no time to do it. If those people aren't prepared to involve one of their own, it doesn't work. That is the big problem. As a lab manager, our technicians need to do their primary job in the lab.

> Don't generally provide innovation facilities for hire as such but do have facilities and will often use them in collab with private companies and spinouts from the university of Waikato. Uni priority is teaching and research, and so private companies using the facilities are in 3rd place with prioritisation.

> Yes. For us it is about understanding their needs. Timing is important, needs to fit around teaching and other research that post-docs and students might be involved in. Sometimes have to prioritise things around. Depending on the project quite keen to help people along the way, in the beginning build a relationship that might lead onto bigger things in the future. Part of our community engagement.

For those that rely on 'soft' money (i.e. grant funding to sustain activity) such as academics, the process of applying for funding is arduous and therefore academics may be reluctant to take on new research if it would retrieve a relatively small amount of funding. In other words, they lack the capacity to take on smaller jobs which could exclude many innovative firms from accessing facilities and expertise.

> Universities function on researchers needing to raise govt. funding – cannot buy out academic time. If you cannot get the funding, [the work/research] does not exist. Cannot function. Most of the time and effort is focused on chasing the next funding bid from govt. Recent example - $20m NZ company looking at certain chemical processes. Put project in front of university group who are capable – would love to do it but cannot, because they don't have the $ to be able to do it. Tension between where they get their money from now and what they need. If there was a critical mass of things coming through all the time then could churn through the commercial projects, but currently don't. They are not set up for it. Tension between research funding and commercial funding. People saying they are not going to get out of bed for <$100k funding. If there is a smaller priced project, they are not even prepared to start on it. Not worth the effort.

Some facilities are at capacity and are struggling to manage the demand for innovation facilities and expertise. The first example noted that biotechnology is one of the areas in highest demand, particularly for workforce.

> At capacity and possibly over capacity in terms of access to innovation capabilities [for biotechnology in the health and food spaces]. Fermenters for example, in high demand. One area that would be highlighted where that is a major challenge for us at the moment. Shortage in facilities and equipment, but also limitations to scientists and engineers to do the work.

> … we don't have time to do our normal jobs as well. There's not enough time and it's not worth it. The best way for people to get access to university equipment is to engage with university from the point of view that you are wanting to do research that is longer-term. That doesn't mean we can't work on optimisation stuff – we have lots of opportunities for students to do research projects. But you need to establish the relationship so there are benefits both ways. Those who can do that can get a lot more out of the relationship. Most of the companies in NZ are a single person with a great idea, but they don't have time or resources to put the time into the relationship with the uni. Those who have managed to do that have had benefits from leveraging the university for analysis, interpretation that are beyond business-as-usual and beyond what they'd get from a consultant. It takes their time and investment.

Those accessing facilities are generally smaller

The innovation facilities in advanced manufacturing tend to deal with a range of innovators, although generally it seems the most assistance and collaboration happens with small businesses. This intuitively seems plausible since larger companies that are well-established likely can afford their own facilities and have the capacity and capability to innovate in house.

> Very frequently small or start-up companies. Single digit number of employees, really because the scale of the facilities we have isn't very large. Even our large-scale
>
> Engineering lab is not very big. And so, any company that had $100k to spend on buying the equipment and doing the work could probably do so. Company turning over $10m a year wouldn't have that much difficultly deciding they need a lab of scale. Only reason they wouldn't is because of temporariness. Tends to be small companies, therefore, that come to us. Couldn't afford to do it themselves.
>
> Interesting mix. Have some start-ups that we work with, one from [university region] as well that came through our pipeline. Use all the different methods for developing their prototype machines they are working on. Use some of our facilities as a helping hand. [Private company] do a lot of stuff with us for special metal 3D printing or large-scale shapes. Carbon printer – if they want stuff like that especially they will come for us. Some that don't know what is going on, and some that want to access the facilities specifically for our expertise or the capabilities.
>
> More smaller companies coming to us. Can vary quite a bit. Sometimes easier to work with than big companies. Big can be difficult – own bureaucracy, ways of doing things etc. When it comes to that type of thing, they are not dynamic. Everything takes forever. Small companies very willing to just pick it up and get the project going much quicker.

Size alone should not always be the focus. An important way of looking at access alongside the size of the innovator is the need of the innovator. For small businesses they often require to be pointed in the right direction – larger businesses that are more established may have the capacity and capability, but just require access to hyper-specific equipment they do not own.

> Blend of companies – big corporates … SMEs as well – probably bulk of work. Got research entrepreneurship spinouts out of unis. Trying to do work with economic development agencies too. Spans full remit. Not just about scale of businesses, but the difference in needs. Get a lot of engagement with start-ups with ideas but no pathway to engage with university system's trying to facilitate the pathway into R&D. Tend to have a more defined need. Nature of conversation varies as much as the size of the firm.
>
> Tend to not be the mainstream players, some other company. Perhaps a niche market, something they are looking to do. Sometimes seems to come through quite a bit – at least half a dozen times a year. We try and get better at advertising what we do. Revamping some of our websites and trying to make it so that it is easy for people to look us up and get what they need.
>
> Range in size. Iwi [clients are] quite large – specially moving towards them with those in geothermal etc. Otherwise range from tiny little spinouts to larger companies. If we can't work with [industry] in NZ easily, then we need to grow them up. Stuff we do is a very small market. Not a lot of [this type of] work being done in NZ. Vast majority of our work is international.

Alternatives exist for some facilities, but not all

In some areas of advanced manufacturing the equipment is generic (or accessible) enough that alternatives exist and there are other avenues innovators can take to get access.

> Don't think we are unique, think that [other] universities would have best facilities.
>
> There are lots of alternatives for 3D printers – it is everywhere. Plenty of different providers.
>
> We have the material ability, mechanical engineering, machine learning, artificial intelligence. If we need to solve a problem, we can tap into a wide range of staff with the right skillset. Resource network that lets us be able to do that too. With that we had our own nodal point where research is based at the uni, and then sub-nodes elsewhere.
>
> There are the other universities that might have similar [engineering] stuff. Similar set ups across them all. If it is particular type of equipment we don't have (precision stuff) sometimes our counterpart from science will have or can point them to another lab or university.

However, some facilities may have more unique offerings with no clear alternatives due to consolidation of technical skill, equipment, facilities, and networks.

> Other groups that might provide elements of what we provide, but we are very unique about having the full suite. Some people just see it as facilities to do xyz. We also though likely have the computational and theoretical expertise to be able to verify the findings. Also have quite strong overseas links. Often with the academics travelling to other centres, they have a more international knowledge base… have been able to expand and build physical capability. Good range of academics involved – networks broad. Really promote us that we will do everything from novel development into production. Performance testing, applications broad. Hard to find elsewhere that would be able to do this, the full suite of testing facilities mechanically and the support around it. The fact that we get a number of international contracts suggests we have leading expertise in some respects.

In materials technology it appears New Zealand lacks facilities for testing and therefore innovators are forced overseas. This does not seem to be a problem isolated to New Zealand, however, as the specific facilities required in this example only exist within the United States.

> There was no facility for testing in NZ as well. Even those producing masks in NZ, no accredited lab. Some of those things happening at national level that hinge on fibres, standardisation, accreditation, performance. Really important. Only place they can get them tested is in the US. Because of the shortage internationally, huge waiting queue for them to be tested in the US. If you were a regular client you could, but new clients couldn't. Was a bit of discussion around at the time of the desire to set up facilities but nothing came from it. Adelaide set one up but not accredited so no one would go there for testing. We have some unique facilities in NZ. University closing the facilities. Economic reasons. Doesn't make enough money. Not enough demand for service, not enough students. In the process of deciding where some of this should go. I think it should be held together. Requires conditioned space for international standards. Have a

thermal testing facility that is the only one in NZ. 2 people in Australasia that can operate the machine.

Most interviewees said that they redirect innovators to other facilities if the facilities they represent do not have the capability, capacity, or facilities to best suit innovators' needs.

> At least 2 examples from a single company where chief scientist emailed people for equipment. If it comes to me, I can send it through to the rest of the network. Can certainly do better through that. Group were looking for a bore mill, had half a dozen approaches. Some vaguely relevant, one for right size and materials though, we were able to find the precise one. Needs proactive people chasing it.

> Do this reasonably frequently. One of the things I encourage colleagues to do is to redirect enquiries to other organisations rather than say no. The next time the customer comes, will come back, even if all we did was direct them elsewhere.

> Doesn't matter where the best team comes from – almost all of our projects we reach out to 8 different institutions. Part of the facilitation and solution might put them in touch with another company – in that case we have done our job. We are not an entity – team within the different institutions. Where we cannot deliver, we go further. Reach out to more parts of the R&D system. Wider answer is that where companies struggle is the next steps. Pilot plants etc. – refer people onward.

> If someone said we need a new material, we would redirect to [other person]. If someone came in with a problem and we could solve with 3D printing, because we have skillset to be able to innovate solutions – we have people who can implement them with design in CAD and testing.

> One of the strengths we have is that we are pretty flexible. If someone contacts us, we will normally pass it off to people who are keen. If I know someone has tech or skills we don't have, will pass them on.

> Also, an integrity thing – if you think someone is better off going to [other research centres] – have to tell them. Each place has its own specialties.

> We have the contacts. Very familiar with that type of work offered by CRIs. Better positioned – better skillset, equipment etc. for that. Can steer people toward Scion, Callaghan, Plant and Food etc. dependent on the nature of the project. We don't do a lot of it though.

> Times where we might collaborate with other labs etc. Most time we are doing testing and things rather than full innovate. Some of our instrumentation, not looking to do commercial work, looking to do research.

> We have bits of equipment others don't have and will come to use, and vice versa. Go to different facilities to use what they have. Group quite small – if there is a capability that someone doesn't have, they would recommend to us, and vice versa.

Facilities are not limited to physical equipment and space

A few interviewees made it clear that it is hard to uncouple physical facilities and human expertise, in the sense that without expertise, facilities are useless. Physical equipment and space require human expertise to be operated in the appropriate way to deliver innovative outcomes.

For some, access to innovation facilities is purely about having access to the human expertise without requiring the physical equipment or space.

> When people contacting us, it is for expertise. Few exceptions – people that have come to us for pilot spray dryer and freeze drier. And also have pilot scale gasifier. Three pieces, but not big business. Very one off and still needs the expert.

Visibility of facilities, functionalities, and expertise available is generally poor

If innovators are unaware facilities (and alternatives) exist, then they are likely going to struggle to get their idea commercialised. Some interviewees from facilities said small innovators are generally unaware of the opportunities and facilities available.

> The small companies generally don't know what the opportunities are. They don't know what test facilities there are, and they don't know how to access things. On the whole, they don't know what to measure, who to measure them, how to measure them, and what it means (across all I have worked with). Have to know that something exists to make an enquiry. University does have lists of experts (not always up to date). Had a lot of changes at the university, and as said before, for companies who have employees with a university background it is less of an issue. For a lot though, they don't. They don't know what to ask for, what exists, what to look for. Need to make sure these facilities are available.

> Some know about it and contact us regularly, but some that cannot see.

> Repeatedly get told by companies they struggle to access [our institute] and get the right people's attention and work up a project in a way that is meaningful. E.g. spent time with senior researcher, when it came to being a project, delegated to their junior student and didn't get the results they wanted. If you had critical mass [of projects] you could plan, not just using the most desperate resource.

> There is an important need for clarity and friendly, open attitude that is not necessarily visible or projected by universities currently. Some doing it on an individual level, but it is not widespread and has not been encouraged until reasonably recently.

There is duplication of resources across some facilities and areas of advanced manufacturing

Duplication of resourcing and facilities could be inefficient and potentially drive facility use-costs higher, posing a barrier for innovators to use and access facilities. This could be linked to the poor visibility across departments and facilities (i.e. silo mentality) and gatekeeping of facility use.

University has been rubbish at buying this infrastructure. Tends to work on faculty-by-faculty request (silo) basis. Faculties work in silos. We have about 10 [of the same equipment] across the university.

No one sharing their equipment with anyone else. Often no mechanism to share – no costing on how these things will be shared.

On that specific surface area analyser, there are some alternatives, but [other facilities] are not very open to having commercial companies use them. That is why they come to me. We use for commercial, but for other instruments for teaching and students only. Happens a lot in the centre, people gatekeeping their equipment.

The point was also raised that universities are trying to do better, and there are some nuances in equipment and facilities that may not be very clear from the outside. What may seem like duplicate facilities may serve very different purposes.

Most unis learned this lesson already. Universities recognise they don't want to duplicate, there is though the need for that to not be a bureaucratic clearing house. There are important nuances in facilities and the need for specifics. Scientists need to go where they need to go – a little bit of 'duplication' is fine but there needs to be communication. Best collaborative networks address these issues.

Some innovation facilities are conflicted in their desire to provide services

A point raised twice is the reluctance of some to provide public facilities and services for particular functions in fear of crowding out alternative, private providers that are reliant on this stream of work as their main income.

One of things not doing as much as we used to is marketing our facilities. One concern is we are taxpayer funded and we go out and compete with people trying to run a business and buy their own equipment. Want to be careful that we are not putting someone else out of business – especially those that we are trying to encourage. Unless it is strictly research, would rather redirect. If some company wants 3D printed component that we know could be done by some other organisation with the same equipment and capabilities, would prefer to send them to those people.

We are aware we shouldn't be undermining 3D printing companies elsewhere. The ones we do regularly are friend companies.

In both examples from interviewees the conflict arose with 3D printing and performing discrete pay-for-service tasks as opposed to innovation assistance. This could further suggest that small firms that approach the public facilities for these sorts of projects may not initially be aware of the alternatives that exist within the market.

Timeliness of access depends on the mandate of the facilities

Overall, the timeliness of access and the process depends on the mandate of the facilities. If the facility is well set up for commercialisation then industry projects likely take priority, or, there are some dedicated resources for industry engagement.

> Timelines for delay wouldn't be months – a few weeks delay at most. Do work for one company coming through reasonably regularly. That sort of work is something we can fit around others. One thing with additive manufacturing is that we can load up machines and do stuff overnight. Got students that can use cheaper and smaller machines. Now, smaller student machines they run themselves – technician looks after those now.

> Access for getting something to market – that is the strong suit of the CRIs. That is what they do well in my opinion. Much more commercially focused than the universities generally are. We are more about fundamentals and focusing on first principals. Generally, how I view the system. Those things that don't need a turnaround in 6 months – longer and harder questions are what we deal in. Where the university strengths lie. For short-term problems they need to solve, CRIs better at doing that. Long-term problems and cannot do it in house, that is where university strengths lie. A lot of the small business projects are not what the uni academics are attracted to (with broad sweeping generalisations). More interested in the fundamentals.

For most university facilities, however, it is likely that the academics' research and teaching mandates take priority and therefore timelines for industry projects could be extended or delayed.

> Tight timeframes especially, might have piece of equipment sitting in a university that would do the work, but is not available to companies or would take too long. Time responsiveness issue.

> Something coming through quite strongly – particularly at universities [they] have timeframes they operate under. Teaching and other commitments – not as responsive as the industrial partner would like. Is about lining up those expectations. In some cases, if you have big enough demand can have a service that has dedicated resource. E.g. for a specialised piece of equipment you are in line with everyone else. Academic needs to know the priority of this work for the client – part of our role to make this known. Sometimes successful, sometimes not. Where it doesn't go well is where someone signs up and the researcher doesn't follow through within the time agreement. The company has some expectations then.

> Getting things done in commercial time frames – looking at delivering things in 3–6-month timeframes. Not an easy way for us to contract an academic on a small project for small time.

> When it comes to commercial firms, all about having it now. Time is money – if they don't get what they want they will go somewhere else. Sometimes we are the last resource. University operates differently to the commercial practice. Even in manufacturing – not always a two-way relationship. Is about us helping them out. Generally, to help people meet deadlines.

Engagement with innovators varies considerably through a spectrum of formal and informal channels

Some innovation facilities have formal engagement channels for finding and collaborating with innovators, such as dedicated research offices within universities, customer engagement managers, or shared innovation facilities.

> [An office at the university] … people that are supposed to be the link between industry and us. If industry came to them, they would direct them to us. Consulting-type work we do is generally done through [the office].

> [Customer engagement manager] has the first touch (front end engagement). Including regional busines partners, ~100 people that engage regularly with innovation partners. Engage, understand needs, identify need for facilities etc. and then point our way to take them on and pull the right teams together. One major channel. Also have a mandate to point customers to other opportunities for accessing innovation facilities (e.g. NZPA, etc. – aware of capabilities and can refer on to some other areas). Vice versa, settings where business might land with CRI or university and are pointed toward [us] for specific technical support. Effort between the organisations to refer between businesses but is a challenge. No consolidated front door for all govt. innovation facilities.

> On campus we have Newmarket Innovation Precinct. Tried to collab with commercial companies to get access to universities, especially in engineering. More focus on people collab with people. Offices or space for companies to come and talk to expert researchers. This year changed a bit. The labs I am working in, going to give to commercial people. Now what we do, get the labs and offer them to commercial entities to get all the equipment and things they need to work on campus.

> Worth noting the mechanisms that we use to engage. One is proactive relationships. Also have science advisory panel – structured piece. Quick turnarounds – set things up in a week or two. Come with a technical problem; our process has this challenge we need solved. We wrap 6-10 scientists with knowledge of that area into a panel – have an hour session where the company presents technical information. Scientists brainstorm and advise on how it could be solved. Will find the right way to go about it, not necessarily solve the issue straight away. Useful front door for our services though. Also, support internships. Recruit from grad pool. Clearinghouse for queries – gets to the right person and then get a response out.

> Also have [university commercialisation arm] who do a whole lot of the commercialisation. Maybe ¾ of the commercial revenue comes from them – they spend the time building the relationships and supporting the commercial things. Treat them like any other research contract we have.

> Bigger companies tend to have more established relationships with [research office].

A large focus of engagement is about building partnership that long-term mutual benefit.

> About building partnership. Engagement is meeting, see what the needs are and what a minimum viable product might be. About building trust and relationship – never stops. Once trust is built, move onto co-development of solution or problem. Once definition, connect. Look to put best teams of scientists and researchers around the problem.

> Driven largely by our level of engagement. Means there has to be genuine interest on company's part. Mature relationship working well but has to develop from somewhere. Small commercial relationship that then we see could be developed into research. Not just doing work for someone. Core composite builders – do long-term PhD projects with us. Looking at companies that do approach, needs to be some academic with some interest in the project, not just to verify the results. Some areas come in that are engineering and not innovation. I have been trying to drive a bit more of a selection process. Historically very strong mechanical testing capability. New rule – if it is not composites, we don't test it. Previously may have tested other stuff. Need to focus on our expertise. Secondly, for young innovative companies we will do the testing stuff for those we are interested in. Not necessarily size or money thing.

> Most collab is either trying to build businesses to sell internationally. Less people coming to us directly. Now moved into space tech area – few more little ones. Seen some of the industries grow – electrification of transport etc. In terms of companies coming to us for small jobs, not [accessing our facilities], but we are not their target market. Interested in long-term collab.

For a lot of university facilities, student research projects as part of degrees (undergraduate and post-graduate) provide a good opportunity to engage with industry and form a relationship that can be built upon over time.

> If student involved who may be sponsored by the commercial firm in the project. Very often in that situation wouldn't formalise the company using the facilities. In that case, quite often the student who may be sponsored by the company. Because student, have access. Easy process.

> We do get some of that. Would see some of that in 4th year research projects. Often where we might test the water and develop a relationship. Both sides figure out if they can work together. Often might develop into post-grad research project. If they can fund a post-grad, they get access to supervisor as well in a fairly low-risk environment. As soon as funding a student (could be through Callaghan, direct, etc.), do have a lot of arrangements that grow into that.

> Had a partnership with some industry for 4th year research projects.

> Other ways to engage – word-of-mouth with industry in the final year projects. Might be talking to industry in specific areas.

One facility we spoke to uses a membership model to provide access to certain expertise and facilities.

> First and foremost, member organisation. Member industry organisation – bulk of what we do is focused on adding value to our membership. With externals, there might be some tasters of the facility offered on an ad hoc basis to upsell the benefits of membership.

Other times the engagement is informal and happens via word-of-mouth, or through personal relationships across all aspects of the industries.

> … although a lot of work comes straight to our scientists.

Sometimes may be a student from previous that contacts us. Degree of separation in New Zealand so small. Word-of-mouth helps to get people in touch with others. To some extent, these opportunities and enquiries just come forward. Academic collaboration fairly organic. University to university encouraged to collaborate, and therefore do research that has outputs that are judged in the best journals etc. Most successful come when there is some personal connection too. Driven by expertise, driven by particular projects – what is the best mix of skills? Trying to fill gaps. Driven by the requirement of the activity.

Mostly people come through to me through word-of-mouth. Gisborne example was in a way informal; loosely connected with the council group, put me in touch with this group. Had a couple of meetings, informal volunteer relationship.

Throughout our network being made aware of new tech all time. Might look to particular industries that may be interested. Being proactive.

Relationships for research projects are very much 1-on-1. One person contacts one person, on a personal relationship level. Conversation starts, they find out we might have the skillset and interest. Just because we have the skillset, we might not want to do it.

Sometimes it comes directly to me. Mostly because they know I am a contact person – go to me and then I can redirect them to whoever I think is the best person for them. May not directly correspond but can put them in touch. Can go towards academics, technical staff, etc. Otherwise might just look at uni website to see the specialist services we have.

Smaller tend to come through word-of-mouth or relationships with other academics who have been going out and trying to get research. Some inquiries come directly to us via contact page on internet.

Word-of-mouth – other students working in same sort of research or had a previous relationship with [university]. Nothing that comes directly to me or the technicians – tends to come via an academic. If there is something that needs to be done, it would generally be through an academic.

Couple of ways we can interact with commercial entities. Direct to researchers – active in the areas they work in. Look at what we are doing, small scale projects to get them in door, and then assess whether there is a longer-term relationship. Some are on informal basis, long-term stuff. Come to use facilities but don't necessarily need the support to use them. Trained by us.

It's straightforward to access the equipment. We are flexible with regard to how people gain access to it. Some people are regular users who get trained and can operate it by themselves – a small number of people are specialists who need full control. Others might be a start-up or commercial company who needs access to an electron microscope but doesn't have the money to buy one. If they are doing development work to get into a marketplace or improve a product, they have had people trained up to use the equipment. The vast majority of people are trying to work out why something is wrong with their product – they send in the sample to be analysed and it's returned to that person to interpret. A well-established process.

One interviewee suggested their facility has more of a 'just-in-time' relationship where innovators contact and engage when they need, and rarely before.

> See our role a little bit to speak into the vacuum that exists, up until the moment they need us.

There is a relatively strong focus on a 'pull' approach to innovation

On a more general note, some interviewees from innovation facilities recognised New Zealand's innovation focus is generally not tailored toward commercialisation and it is something often struggled with.

> Commercial outcome not there often in NZ – because we put a lot of time as a country and effort into the actual science, but not into the commercialisation. Think about it as commercial backwards rather than science forwards at [our facilities].

To try and improve on commercialisation, identification of market gaps and 'pull' approaches to engagement are necessary.

> If you can identify a market gap and identify how much the market are willing to pay for it, you could be a lot more successful. Different to push science where you are making cool stuff that doesn't fill a market need. If you have the market intel up front, you can see what need you are filling.

Some interviewees made it clear their facilities have a relatively strong focus on a 'pull' approach to engagement and innovation – an active and concerted effort to find innovators that solve existing issues (i.e. working from the end user back toward the innovation, rather than blue skies innovations that do not necessarily solve existing issues).

> Looking at the process, quite happy to go to the edge of valley of depth with the proof of concept. We are design-led thinking. All about bringing in all the people involved in the problem, find out the issues, and then working with the end user at the forefront of development. Always been our approach.

> By way of history, when we put together our research programmes we often go out to industry. Identify some areas common across the different companies, the interests they had. Produced research programme from those issues/areas industry talked about – flammability, moving composites up value change, defects etc. Trying to convey that unlike a lot of the university parts that satisfy the university and academic interests, we try to align our work quite hard with future looking advancement of industry.

> Yes, we do research, but we have an external lens, we see working with industry as our bread and butter and have actively sought to collaborate with universities and others.

IP procedures are sometimes in place to try and incentivise collaboration, but not always

IP control was raised as a significant issue by accessors and seen as a barrier for accessing innovation facilities.

There is a lot of variability in the way IP is managed and shared amongst innovators and facilities. This likely depends on the mandate of the facility once again. Overall, most facilities seem to have standardised channels for dealing with IP such as research offices or IP managers, and non-disclosure agreements (NDAs) to manage concerns as best as possible. Experiences with IP management seem to be a mix of positive and negative.

> [Innovators] would go to [research office]. IP normally belongs to company funding the project. Within our research that isn't funded by industry, [IP] shared between university and the academics and students working on it.

> At [crown research institute] very clear we don't own the IP. Goes with the business who employs us – by mandate.

> Trusted relationship before they even arrange it. We put NDAs in early on. Science panel is non-confidential. Once NDA is in place, both can share exactly what level of IP they already have. Then, you negotiate what can be done to leverage existing, or to jointly develop new. If the company is paying, relatively simple – they get all the newly developed IP. If they cannot pay (have to go funding agency), there is a risk that they struggle to own the IP. Callaghan mandate is good, company gets it. If MBIE though, then it becomes harder. Company may be able to license it but will not own it.

> Mostly has been resolved. If someone comes to us with a design and they are worried about it, we sign an NDA. [University] stamp of approval. Good confidence booster. They do the work, they own it. Design and development work, we are very happy to sign over the IP. Just do the R&D – they pay for it; they own the IP. If we come up with something, we choose whether to protect it or not.

> Many starters name us as co-inventors, as acknowledgment, and they may offer us an interest in the company, but we do not seek it.

> Go through research office. They manage IP issues. Even in some cases might be via the research office anyways when dealing with industry.

> We agree generally upfront when doing any commercial work specifically for them that they own the IP. In larger research programmes with collab, when we bid for funding we agree afterwards about IP and sharing. Generally, expect with govt. funded that IP is split equally. Generally been able to work through concerns. Never had anyone pull out because of sensitivities around IP as far as aware. Universities not particularly secure because of the way they are set up. Partly because of our centre culture, much more aware of how that information needs to be protected and used. Got a lot more procedures etc. than other areas of the uni. Aware some companies are concerned with that when dealing with a uni. IP shared in a regular way unless otherwise contracted.

Some universities and other innovation facilities may have licensing arrangements or different mandates that confound IP issues and could disincentivise collaboration.

> Likely another point there about the IP ownership model [and differing mandates] – universities will sit and hold the IP and share with the academics. Then becomes about making the value out of the IP. Opportunity about publicising the IP that we can then make the IP useful and fit gaps, rather than CRIs and universities trying to exploit it themselves.

> Again, variability around handling of it. Often find NZ businesses have the view of owning everything. Often not always possible – University sometimes contractually bound that it cannot assign IP but can license. Equally valuable and powerful. Has the same values as

ownership. Other odd thing about it, is that as a licensor, the university will fight to uphold our rights on behalf of the licensee. University often has a lot deeper pockets. Degree of education etc. needed around IP. Quite good at this, know the issues and can explain and talk about it. Have to have the trusting relationship. Some people otherwise aren't trusting.

Bunch of things in here – degree to which it is well known and understood. Other thing around flexibility. We have some flexibility about how we can manage IP. Other issue is around students, we do not own student IP unless agreement signed prior. Interesting because getting students onto the projects sometimes complicate it because they are cheap but keep their own IP. Have to equip students with the knowledge and conscience about managing IP.

When people come through as companies, they should go through [our commercialisation branch]. They deal with the IP. Then people have to sign up to the IP regulations. That's why the people who get the most out of it are the ones who get trained and do their own analysis. As long as we know there's no safety issue, we don't have anything to do with their analysis, so they can keep it under wraps. If we have to do background research or understand the material, it becomes a minefield of IP.

NDAs in place. Can change how the project develops. Who will own IP at the backend? Is all negotiable. Gets interesting. Companies want to do things on the cheap with students but want to own all the IP at the backend. We sort out IP up front. Students need to be able to publish, especially if post-grad. We have structures where theses can be embargoed for 1 or 2 years. Some companies have plenty of experience with that, others it is new for them. Sometimes have to walk them through and suggest the nature of what they want to do is not what a student should be doing (if sensitive). At that point they baulk because it gets a lot more expensive. No one can ever guarantee IP. At the end of the day someone has to publish. Some of the aspect has to be published. Some companies comfortable with that, some not. Extreme, doesn't come up often. Normally can talk through and come up with an arrangement. Do like the companies to know that though. If they really want it locked down, they shouldn't do it here.

Depending on the nature of the results, there are instances where research is embargoed. Protecting some IP. Would be acknowledged up front.

Some innovators fail to realise the trade-offs being made when they opt to hire students instead of academics at lower cost (the trade-off being between cost and IP ownership).

Classic when they want a cheap student and want to own all the IP at the end. I won't sign off on projects like that. If so, then we should be looking at full cost recovery. They have probably gone to a CRI first and got put off by the cost. Get access to student, equipment within reason, and get access to supervisor who is involved in the project. Have to remind them of this – not paying the full cost of the research. Every department handles it different. At that point we have to look at a shared IP arrangement – not paying for supervisor or equipment time. Some say that is fine and are willing to do that. Depends how sensitive the material that you are going to provide us is. Anything you provide us is yours, but a university is not as confidential of an environment as a CRI. If you were that concerned about your IP, then possible the university is not the best place to do that.

Previous bad IP experiences may also make innovators reluctant to engage or make the process of engagement more difficult.

Some that don't trust – is a problem. Burnt in the past. [Two bigger players] – notoriously difficult to get a level of trust to work on their things. Some of the bigger ones feel they can get there themselves. It is the smallest that have to either trust or miss out on an opportunity and struggle with it. That is why the NDA is important. Sometimes still do express issues about IP leakage – raising concept and then someone 6 months later working on the same thing.

Some had old fashioned ideas about IP, being very precious. Can spend a lot of money protecting IP when it doesn't eventuate into anything.

Ways of costing access to facilities are variable

Some facilities are quite informal in the way their equipment and expertise are costed. In some cases, services and facilities are provided free of charge and when there is spare capacity at the facility.

Depending on who and how, sometimes companies get charged, sometimes its informal and gets done over the weekend for free. Patchy – trying to enhance that sort of access. Primarily a fee for service model at the moment. Flexibility in pricing to some extent – the uni wants to recoup some of its costs but sometimes the companies aren't in a position to pay full costs. Subsidisation sometimes that isn't fully recognised. Transparency important. Some of these service offerings we are developing will have much more transparent pricing. Some of these things happen so infrequently that no one knows how to price them. We don't want to be crowding out commercial players as well.

If they can do it through a student, then there will be no extra charges. See the university as providing social support. University gains from having real projects. and students get offered jobs there. With start-ups, it is a free service, usually it is my efforts that go into it.

All over the place, no one set model. Commercial relationship managed by university research office. If it is consulting, research project, etc. if there are industries involved and a contract needs to be signed, then the contract is managed by university research office. Whatever the department, manage the contract and make sure the documents etc. are signed. Payments are managed, etc.

Depending what it is, some things may be charged for, some not.

It appears costing can be quite difficult and inconsistent especially with facilities that are not used often or in a routine way.

If company doing the work in our labs and relatively little involvement by researcher time, then we would typically do separate charge for facilities. Because doesn't happen often, don't have a fixed formula for it. Bespoke arrangement.

Contrarily, some have standardised ways of costing access, usually done through contracts and on a pay per use basis.

Where no student involved, can be collaborative research with our researchers. Again generally done on basis of contract research agreement. In that situation, mostly the company would be charged for time, overhead, operating costs. Wouldn't be separate charge for facilities. Covered by overheads. The way that we have done in past is have said if this company staff member will be working in our lab for this many hours, if they were our staff and we were charging overheads, then what portion of that would be paying for facility? Work it out on that basis on their hours and the overheads to charge on them for staff member. Rough and ready way to do it.

Once we get to defining a tightly scoped piece of work and delivery, that is contracted through the institution leading the project. That is where the company pays us commercial rates for the delivery – around time, facilities, and resources.

… have pretty standard contracts. Allocate someone FTE and then equipment and technical support costs, will include the different things you might need. Overheads included. At the end of the day, standard contract. Go through what to do, time plan, who and when, what equipment, etc. Stage gated – phase 1 is half the money, then goes through into the next phases.

Typically, service-based fee. Could be a combo of time and resources dependent on what they need.

Generally, fee for service though for the facilities listed on the website. Happy to have long-term contract with some companies… pay annual fee, can use it up to certain limit every year.

Costs of facilities may be prohibitive for some, especially at universities

An interviewee from a university reaffirmed that university cost structures may be seen to be prohibitive to some innovators, therefore forcing them to go to other facilities.

Resourcing – number of entrepreneurs that come to us and really cannot afford a project through a uni. At one level not a surprise, but there are some substantial project being missed because of uni pricing structure. Uni overheads of 100-140%. If there was a funding mech that we could charge professor time, and the overheads was covered some other way, would leverage what we are doing quite extensively. The argument that overheads is there in the first place because govt. don't fund universities. Restricts us at the moment – baseline funding we have is shrunk because of overheads.

Naivety and/or unfamiliarity of innovators with research and the commercial innovation process

One interviewee suggested that innovators often neglect extant literature and patent information as a valuable source of information when directing the path of their innovation. Some of this may come down to the innovators not knowing where or how to find literature and patent information, and also not knowing the value of conducting a literature and/or patent search.

For NZ, important to recognise that multinational companies use literature and patent information in a proactive way. NZ companies often don't. Need the scientists to know about these things. Even for some, a literature or patent search is important.

The second area of a lack of knowledge seems to be around IP; particularly in how to recognise, manage, and protect it. IP leakage has been highlighted as a great concern for both innovators and facilities and may be a barrier to engagement.

> [IP leakage] is a risk and needs to be educated about. A lot of naivety and sharing of information that shouldn't be all over. Burning issue that needs upskilling. Training right from day 1. Within PhD start giving them individual advice, and training sessions on IP – how to identify it, how not to disclose, etc. – some researchers not interested. As we develop more commercially focused work, there needs to be a bigger push. About people caring – used to be a naïve aspect about NZ doing research without caring about patents etc. MBIE criteria about reaching impact at the end of a funding proposal – now much more serious approach and seen as competitive part of funding bid. Starting to see a group of dynamic people and leaders that are interested in it. We have to be well informed. KiwiNet put up a post about upskilling our commercialisation professionals. Don't think it will be costly for commercialisation offices – IP lawyers on their teams. But need a deeper understanding these days.

Other areas of naivety may include a misunderstanding by innovators generally of the costing of accessing facilities.

> People expect to get it from the uni for a cheaper rate than from a consultant. For metallography, for example, there are commercial people who do that, e.g. failure analysis. They are much more well set up to do that – not from equipment point of view but from experience point of view. This is a particular challenge – they expect to get it cheaper from the uni. People think that they will get a high quality, cutting edge report from a university. In reality, people come to NZPA, meet a professor, but a PhD student does the work. It's not a professor's analysis. It's not what people are expecting.
>
> Most people want something for nothing – seems to be the main thing.

One interviewee made note that innovators often expect universities to act as consultants and have a pre-conceived idea about the innovation process that often does not match the true process.

> [Public-facing research group] are supposed to leverage our lab equipment, but it doesn't work. If you have a company that has people on board who understand the analysis techniques and know how to use it etc, then it can work. E.g. ex-students know what they are doing. Can use and interpret. The vast majority of others, e.g. small companies with a big idea, know they need the information but they don't have the background on the equipment. They expect to come to the uni with a problem and leave with a solution. They don't expect to be trained on the equipment and learn how to interpret the raw data. They want the uni to solve the problem. That is understandable. They expect us to be like a consultant. We're not set up to do that.

Managing demand for facilities is a delicate balance

Management of demand for innovation facilities is a delicate balance and requires good coordination between those that need access to capacity and capability, and those facilities that have it. If there is ill-coordination, then it is likely that the facilities run inefficiently and that innovators are unable to get the access they need.

> Number of important things to get right – one of them being not having them utilised too much. 70% utilisation is good, 80-90% not good. Someone coming in who just needs the 3 days on the machine are going to have to wait a lot. If it is at 70% then it will be easier to get on the equipment. Don't want it too much less though, otherwise not economic (higher costs per use). Need responsiveness and reasonable cost, balance it. Requires continuous business development with dedicated people. Continuously out there seeking out the next company making use of the facility.

> The fact is there needs to be something to match [need and capability]. Really easy for us to think let's make a list with a database – no one wants to look at that. A lot of success of this has to come from personal relationships, meeting people, talking about it, and becoming an advocate for the R&D system. Can work both ways.

Funding for facilities is consistently under threat and may limit future capabilities/accessibility

A lot of facilities rely upon government funding to be able to continue to research and provide facilities and expertise to innovators. This funding comes in the form of MBIE Endeavour grants, Catalyst grants, and other core funding that all require the innovators to go through rigorous application processes.

> Risk is that if we cannot continue with similar levels of grants with MBIE will lose certain capabilities. Academics continue to fight for funding so might be able to take forward.

As the government of the day changes, so too might the priorities of research and whether the focus is on industry problems or blue-sky-type projects. As a result, typically funded works in advanced manufacturing may not be prioritised and may not receive the same level of funding, casting doubt on future capabilities and accessibility of facilities.

> When we ask for such big programmes have to have strong case. See cycle with time that pushes from industry focus to non-industry focus. Maybe fell out of phase a bit with the application cycle (wrong place, wrong time). MBIE previously used to indicate where funding allocation was too. Have stopped indicating. Pooled for all. Looking at results from Endeavour now, hard to find advanced manufacturing in it. Multiple in forestry etc. Little that gets funded now in the competitive funding pool that is advanced manufacturing.

Some sort of visibility about how much funding is allocated to research and where it is allocated would be useful for future planning.

> Even better if we knew how much of the pool is available to us. Rather than unclear.

One interviewee suggested that a proposal they had put in with other researchers was rejected which was disheartening and led to a lot of lost interest in Industry 4.0 (i.e. the next industrial revolution and digital transformation of the sector).

> Have the MaDE organisation – each year have MaDE conference. Various universities and research institutes + industry get together. In that, we put together a core application. Big funding thing (centre of research excellence, collab with Callaghan and other unis). Put it in and it got rejected – didn't know why that would be. The govt. should be funding

> manufacturing – right down the middle of exactly what they were talking about, and it got rejected. Happened last year. Huge amount of effort gone in to putting it together, gets everyone working together and collaborating; right into advanced manufacturing with Industry 4.0 and stuff. People now that were leading that have lost a bit of interest to go ahead and do it again which is sad for NZ.

In some cases New Zealand may miss out on the innovation because of the misalignment of industry and government wants, needs, and opinions.

> A lot of infrastructure that exists, that if it isn't in NZ, people will go offshore. Involved in discussion at [university] with group that wanted some testing done. They were checking the costs of having work done in NZ and UK. Bidding war – gone to have it done in the UK. We are losing the capability and opportunity to encourage these companies to further develop things in NZ. We have textiles etc. as the second priority for MFE for waste. How are we going to measure those things when the products come in etc. without the infrastructure?

Finding capability in New Zealand for niche areas of advanced manufacturing may be hard

There may be a shortage of expertise in some areas of advanced manufacturing that could threaten facilities' future capacity and capability to help innovative firms. As one interviewee said, this is a problem that existed before COVID-19 and the associated lockdowns and border closures and is likely a more systematic problem about human capital retention and development in New Zealand.

> Hard to find people to do the work. Growing as many possible domestically but expanding beyond that. Realistically would have to get people from overseas anyways. Never used to be a problem to get them in (COVID).

As with the first example, innovation activity is likely constrained by the inability to find appropriate expertise with capacity, especially at universities where academics have teaching responsibilities and their own personal research.

> It's the people [as a constraint]. There's flexibility for equipment/time. It's just getting someone to do it. If you don't have a good background in preparing samples, running and interpreting data, you don't understand. Takes a lot of work to get just one data point – there's a disconnect in their expectations. In reality, it doesn't work well because you need to have the background and experience in preparing sample, running equipment, interpreting the data.

Those accessing innovation facilities – Forestry and Wood

There were four major themes identified from users of innovation facilities. These are detailed below.

Cause for concern from users in the way IP is handled

> We just want a few machines developed. There's also the question of who owns the IP and whether it will be supplied to competitors.
>
> Another tension with Scion, they have had this mandate to commercialise technologies and IP they generate. Have tensions between industry and themselves i.e. you look to develop IP with them and then they go sell to someone else. This is not necessarily the case with everyone, but there is that feeling as have history of selling technology to highest bidder.
>
> Whatever research we do, even though we pay for it, they own the IP.
>
> The ownership of IP issue is somewhat discouraging. Is an interesting issue as from my POV, Scion or UC can't develop or innovate something if don't know what it is, these ideas lie with me. Design and testing need to be derived from an original concept, which would be from me. So I know how it's going to work and what it's going to do, yet don't get the IP.
>
> Had a proposal from forest growers levers trust. The IP issues and exclusivity are quite discouraging. The problem now is technology has evolved rapidly. I find it easy to get there quite quickly by myself due to environment, so reliance for need of institution that wants to hold all the IP doesn't hold a lot of value. I have a budget that is not massive and can have good outcomes and quite quickly doing my own R&D.
>
> The reason we are with the University of Canterbury is Scion wanted control of everything, whereas we wanted industry control of programme.
>
> There are tensions that come back to IP. Issue that comes back to is who owns it. There was a view that the biggest mistake that Scion made was not holding onto IP for things e.g. germ plasm, where this now resides with industry. They need these income streams and have to rely on seeking funding from MBIE and industry.
>
> The real impediment is that some scientists think it's their IP, since they've invested decades in, they don't always let go easily.
>
> IP created by CRIs should be held by an independent company. Currently all forestry levy research is held in trust by Scion. Bad idea, Scion has a conflict of interest and won't let it go easily, they want to wring every dollar out.
>
> The IP belongs to taxpayer or levy payers not Scion.
>
> I don't believe in the current commercial funding model; it has to return a dividend to the government which puts a lot of pressure that complicates the relationship with industry.
>
> **Relative to overseas:**

We are doing some work with a research institute in Norway – developing an eco-friendly modification – they have a commercial arm but the conversations you have with them are open, sharing of IP is balanced. Whereas with Scion get feeling they are out for themselves.

Speed of access and process is typically slow

We have tried to engage with Scion on many occasions. Lots of nodding and smiling faces. But nothing happens in the end. This may be due to us not having enough money to invest.

We have done a couple of projects with Callaghan but their application processes are very stringent and difficult to navigate. It's way over the top. They're too hard and aren't interested in experimentation.

Scion has a really important place, they have a reasonably good brand, a good standing domestically, and internationally, people know who they are recognised but not particularly well liked. There is a feeling that they are a little bit behind the 8 ball in global innovations. This is only recently, 20 years ago they were leading edge. In the last few years, there's a feeling they've dropped the ball a little bit in wood product side, not so much on silviculture and forestry. They're listening at conferences rather than offering solutions.

Have to dig quite hard to know the value they [Scion] can offer us. They are very non-committal in terms of giving statements on product.

BRANZ also exist and don't have a commercialisation imperative. Sometimes a bit misguided and go off on tangents – in comparison to Scion they are a whole lot better in this regard. BRANZ are hopeless to deal with, to get anything with speed is difficult. Overseas more commercial set ups and can get it done within a week.

Have to have expectations around timing, don't want a hurry.

We are struggling to get information out of them [Scion]. They are cumbersome, personality driven, legalistic, slow. Won't work with them again until this changes. Major problem is they are not set up to deal with people like me.

Potential solution:

In the 80s there was a thing called taskforce, a temporary collections of people from Scion and industry to work through a specific problem. Was a collection of people who were put together for 3 years, told them this is your target, go do it and let Scion know what you need. Task force gives a focussed effort, multiple disciplines are brought together and a finite life to achieve this. This worked.

For new and small to medium users, accessing the right people can be difficult

We're disappointed with Scion and don't see them as friendly, usable or applicable.

As a whole, trying to navigate the corridors of Scion, trying to figure out who it is you're supposed to be talking to, to get value out of them, is a challenge.

There is that communication element that needs work on both sides. This guy who used to work there made the real effort to keep relationships going, don't see this anymore. Maybe because we are not as big as Timberland or the other bigger guys.

Big access issue I want to address is access for small growers to technology. My interest is how do we improve NZ through forest small grower enterprise.

Big guys largely knew who they could work with and where to go. But not the small ones.

Solution:

There would be value in having the right person who knew what they were doing. They have tried this there; they had a business development manager who has left. I don't know why but didn't get much out of him. Prior to him, had a more commercialisation guy, he was good. Need to connect not just Scion but other CRIs.

There is a good role for a principal technologist as a networker at the front. You were expected to know everyone and everything in a general sense (not all specialities). A very good idea.

Genuine value in the role but potential to get so busy that you spread thin, and budget blows out. When Callaghan had one of these roles, this happened, and they stopped supporting it.

Established relationships help in accessing the right people:

Been dealing with them for 30 years that we know enough people. Even if an area they don't know, relationship good enough that they will run around and help me out. This is not purely a Scion problem.

Costs can be significantly higher than overseas

Scion's people are focused on publishing their science research. Commercial research is very secondary. If you invest $1m there you'll find most of it is chewed up with wages.

We go to Sweden for durability testing. It is quicker, cheaper and certified in Europe. Can do this in New Zealand but may not be certified.

The other thing is price, some of the quotes 4 to 5 times what we get in Europe, and in some cases not certified. When have a 3rd party certification agency come in verifying methods. All they have is the brand. Whereas overseas have an IENZ verification.

Pricing is a stumbling block. There is the method, cost and third party verification side of things. We have IANZ in NZ, but there is a lot of things they don't have. They'll tell us say it's not worth it cause don't do enough volume, fair enough, but reality is if don't have it, hard to market offshore without it.

Scion's work is very expensive.

My view is Scion is expensive; they are small and have an overhead. Common problem in NZ is that we only have 5 million people. If you want to engage Scion won't be cheap, but we also want quality.

Consequence of too expensive:

We have worked with the University of Waikato. It's a poor man's solution. It can be very time consuming and not well focused on the needs of the business as the students are wanting their degree rather than to help the company's R&D programme. We had one project that worked very well while the other was aborted and was a very negative experience that cost a lot for a little.

Focus should be more on providing solutions to industry problems

They [Scion] have this internal focus with R&D where they go off on tangents to go and develop these technologies without industry consultation. E.g. have a press release, and we'll say why didn't you tell us, and they'll be surprised were interested. They'll take 2 weeks to reply to us, then when we finally hear back, find out the technology isn't feasible. Few examples of this, and look at and wonder how much money they invested in it – see it's a cool idea for a scientist but won't work in real world. Engaging with the industry a bit earlier would be much more effective.

Unless we pick specialised areas to be best at, we will always be at margins of world science. The reality is that we are a small nation at bottom of world, if government doesn't invest strategically in natural assets, we will be in a bad way.

Scientists that come from an academic environment – immature in commercial regard. All about investigator led components, when bring them into mission led environment, don't understand these requirements.

They [Scion] need to go to industry and find what problems are. Don't do this, spend all their time finding funding for their next research project.

One of my biggest issues is the environment Scion has to operate in, they have to beg and steal from MBIE. This is very frustrating; a lot of time is wasted writing and rewriting bids. Is almost like you have to have result before you put bid in, whereas in reality you don't know what you are going to find.

Most of their game should be adapting the latest and greatest stuff coming from overseas. Adapting for NZ conditions. Can't always come up with latest and greatest ideas.

Instead of inventing, go out and see what other people have, modify it for local environment and use it. They don't spend enough time looking around. Most of the problems aren't new.

Those providing innovation facilities – Forestry and Wood

There were four major themes identified as issues with the accessing forestry and wood innovation facilities.

Commercial funding drivers can cause issues with IP

Because of public funding, there is level of complexity coming from Wellington. If Government is investing, there needs to be some consequences of IP. Another challenge is that a lot of CRIs looked at plant and food with a huge degree of envy – through licensing with Zespri, they were receiving 30 million in royalties. but broadly speaking wasn't tied to wellington bureaucracy (moving way form this now). All CRIs were trying to replicate the plant and food model, Scion definitely was.

The IP developed has been codeveloped with industry. This creates a problem with the IP landscape, what do you say when industry entities that contributed wants some of the IP.

Funding model inherently driving some behaviour and needs to change.

In the past, had idea to secure as much IP as possible to get independent revenue streams.

Counter argument:

Making IP available for others early on – big driver for others to use not for Scion to get rich.

In some cases cannot make technology available to one partner, need to look at IP from a benefit sharing perspective.

Evidence of recent change:

This has mindset has changed. Now are focused on the true impact of research, of delivering value to others, not value to Scion.

Over the last year/18 months, have made effort to make IP transaction as easy as possible. This is done to maximise benefit to the country, which is much more important than a revenue stream.

Commercial funding drivers can de-prioritise smaller firms

When there is competing for funding, people can get upset.

Little guys might establish a new industry, but it is a lot harder to build a one billion dollar industry than add another billion dollars to an existing industry. Scion needs to decide where they will build the most value.

We deal with big people in a regular basis but don't take all capacity.

We are competing with the big projects e.g. Radiata Pine Breeding Company and FOA. So we mostly fund our own R&D but we lack the skilled people to run these projects. Capex is in short supply and it's very difficult to get projects over the line.

Is it better to deliver a new entrepreneurial outcome that may never generate than a few million in revenue or add 15% to an existing large ones.

Distinct lack of scale-up facilities

The biggest obstacle for New Zealand is not having a pilot scale facility in the middle. A pilot scale facility would help take from lab to commercial, would help to de-risk it. Pilot testing is expensive. Example: saw a start-up have to buy $100,000 of stainless steel, whereas should be able to hire it for a few thousand from a pilot facility.

NZ needs something like this [pilot scale facility]. All other major primary industry companies in world have some sort of bio pilot type facility. Almost 100% are either public funded or have a large amount of public funding. Industry uses them but they are not a for-profit organisation.

I don't feel UC is strong in entrepreneurial and incubator type space and getting things going.

Scion has very close partnerships with crown institute in Germany who run the largest bio pilot facility in Europe. They provide advice.

You need to take innovations close to industry. Thinking about piloting and demonstrating things even before industry accepts it. Bio pilot is an example.

Our role as research organisation is to de-risk things. We got some overseas machines on site, when the industry saw this, gave them idea to invest. If we bought machine and it didn't work would have been fine. There was an example of a specific system, where if a firm had bought and tried tailor it to themselves and it didn't work, would have been a disaster. I agree that piloting and demonstrating is a gap

Argument against:

Regarding the debate on Food bowl and use of something similar in a forestry sense, it won't be suitable as forestry too specific and too hard to achieve economies of scale as easily as in food and Beverage.

Focus should be on industry problems and innovation technology that is appropriate for use in NZ

In a CRI, academics or scientists will just work on what they think is important. Need to ensure the work is delivering value otherwise why have CRIs. [Scion] Was slowly becoming more and more introverted, saying they want to work on things when they want to. This attitude is starting to change, new approach is much more top down rather than bottom up.

For a CRI to deliver impact need to be Horizon 1 or 2 thinking. Leave horizon 3 to universities, the Government should say if Horizon 3, give to a university.

It is important to listen to what the industry problems are

You'll hear industry get frustrated that all industry thinks about is publishing. But what it does do is if you publish in right venues – makes sure work is world leading and world standard. It is sometimes a mechanism of making sure we aren't just world famous in New Zealand.

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