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Te Kōmihana Whai Hua o Aotearoa

Frontier firms: Four industry case studies

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The New Zealand Productivity Commission

Te Kōmihana Whai Hua o Aotearoa[1]

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[1] The Commission that pursues abundance for New Zealand.

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Overview

This paper summarises the findings from case studies of four significant New Zealand industries: Dairy (both farming and processing), Health technology (HealthTech), Horticulture (with a focus on kiwifruit and wine) and Software products and services (Software). The work is an important part of the evidence base for the Commission's inquiry *New Zealand firms: Reaching for the frontier* (the inquiry) (NZPC, 2021). The four case studies have identified various opportunities for improving productivity, some industry-specific and some generic. The Commission's policy recommendations for addressing these issues are in the inquiry report.

Part one of this report sets out the context for this work, how the four industries were selected, and the research methods used, including some explanations about the data used. Part two describes each of the case-study industries and summarises the authors' findings on each of them. Part three draws out some key insights from comparing and contrasting the industries.

Four significant industries

The Commission selected the four industries based on where productivity improvement could help materially "shift the dial" of New Zealand's aggregate productivity performance. They are all exporting industries of significant size or with high-growth potential (such that they could become significant contributors to the economy in the medium term).

The four industries comprise two traditional industries (Dairy and Horticulture), based on deploying high levels of tangible capital (assets such as land and machinery), and two more "weightless" industries, underpinned by intangible capital (such as software and intellectual property or IP). This distinction explains many of the key differences observed between the industries. For example, the weightless industries of HealthTech and Software generate products that have a high ratio of value to weight, giving them significant advantages when it comes to exporting from a remote country.

The traditional industries have driven export growth in the past

Dairy is a large industry in the context of New Zealand's exports. It has high labour productivity, which is related to high levels of capital investment and land. The industry gains the scale necessary to enter overseas distribution networks through New Zealand's largest firm, the cooperative Fonterra. The industry has grown strongly in recent decades based on increased volume. Continued volume growth will not be possible due to environmental limits, so in the future growth will have to come from shifting to more distinctive, higher-value products. Achieving this will require investing in innovation to get more value from a given volume of milk, but this has not been the focus of the dominant cooperative Fonterra and its farmer-owners in the past. However, the new Fonterra leadership accepts the need for change.

Horticulture is made up of many different crops, but in value terms it is dominated by kiwifruit and wine. Zespri is the cooperative of kiwifruit growers with a statutory right to be almost the sole exporter. It acts as an anchor firm for the myriad of growers and other supporting firms, helping generate and protect the intangible assets of the industry, and providing sufficient scale for the industry to be at the global frontier. Zespri's approach to innovation and diffusion, underpinned by a strong customer focus, smart branding and long investment horizon, provides a model for other industry organisations.

Like kiwifruit, the wine industry has a strong and well-recognised national-level brand that is trusted by consumers. It has a well-regarded industry body, which provides cohesion to the industry and a dedicated research institute. In contrast to kiwifruit, the wine industry also has several large, multinational companies providing scale. However, with static prices and rising costs, the wine industry risks falling into a commodity trap.

The traditional industries have historically provided the bulk of New Zealand's export revenue. Despite strong export growth potential, dairy, kiwifruit and wine are all facing capacity constraints in seasonal

labour, suitable land and water. This accentuates the need to focus on productivity growth through premium products and continued innovation across the production and supply chains.

The weightless industries illustrate future potential

For the weightless industries, wages are higher, as are rates of innovation. However, measured labour productivity is lower than in the two commodity-based industries. There are at least two reasons for this seemingly puzzling result. First, Dairy and to a lesser extent Horticulture are more capital- and land-intensive than the weightless industries. Their capital is also tangible and so is more easily measured and captured in statistics. Having more capital and land for each worker in Dairy and Horticulture to work with makes their average labour productivity (the value of output per worker) higher. Second, it also reflects the fact that many firms in the weightless industries, particularly in Software, are still relatively young and small. Small firms are not included in some of the datasets used in the Commission's analysis; and young firms that are included may not yet be generating income. Their measured value-added per worker could therefore be low or even negative at this stage of their development.

HealthTech is highly export-intensive and its export revenues are growing fast. The success of the industry has been driven by its anchor firm, Fisher & Paykel Healthcare. Despite their exporting success, firms in this industry face significant regulatory hurdles to entering new export markets. By contrast, the regulatory settings in New Zealand appear to have been favourable to the industry's growth, if only by good fortune. A significant domestic constraint is that most District Health Boards (DHBs) – who are important potential testbeds and customers – have no mandate or inclination to support local innovation in the industry.

Software has been growing strongly in both the domestic market and in exports. The Software industry has the highest wages of the four case-study industries and has maintained that position, despite the number of firms doubling and employment tripling over the past two decades. There are some indications that Software firms face lower barriers to exporting – suggesting the industry is living up to the hope of this weightless industry to reduce the "tyranny of distance".

Weightless industries have different financing needs to traditional industries, relying more on equity capital. "Smart capital" (knowledgeable, specialised investors) can be hard to find in New Zealand. However, the main constraint to continued growth in both these industries appears to be the supply of skilled labour.

Government supports for innovation can be improved

The innovation ecosystems of these four industries are all different, yet each innovation ecosystem is crucial to the success of the businesses within them. As a result of historical initiatives built up over decades, some industries receive a lot of direct government support (for example, via research entities), while others (especially newer ones like Software) receive relatively little direct support.

Some good practice is evident in the innovation ecosystems. For example, the longstanding relationship between the Crown Research Institute (CRI) Plant & Food and Zespri has clearly been instrumental in developing new fruit varieties. The HealthTech innovation ecosystem seems the most functional. This may be due to its small size, high levels of training and research funding, and the involvement of the MedTech Centre of Research Excellence (CoRE), although government funding for this entity is about to end.

The case studies revealed ways in which government supports for innovation could be improved – both at a system-wide level and in specific ways for particular industries.

At a system level, industry stakeholders across all four industries told the Commission that the suite of government programmes to assist firms with innovation and exporting is cluttered and confusing, with both gaps and duplication. The Commission makes recommendations for improving the coherence and accessibility of these supports in Chapters 5 to 8 of its frontier firms inquiry report. Firms in all industries

also struggle to find suitable skills, including advanced research skills and management skills. Chapter 9 of the inquiry report makes recommendations for tackling these problems.

Chapter 10 of the inquiry report makes recommendations for easing regulatory constraints on innovation identified through the case studies. Some of these recommendations are industry-specific (such as around the regulation of Fonterra and the mandate on DHBs to participate in local innovation). Others have broader scope (such as around the regulation of genetic modification (GM) and consumer data rights (CDRs)).

Part one:

Setting the scene

Part one sets out the purpose of this work and the methods used.

1 Introduction

1.1 Purpose of this report

The Productivity Commission is conducting an inquiry into how to maximise the contribution of New Zealand's frontier firms – the most productive firms in the economy. As part of this inquiry, the Commission has undertaken four case studies of significant New Zealand industries.

The purpose of these case studies is to understand, describe and compare the productivity performance of the selected industries. By confining analysis to defined industries, the Commission was able to explore key drivers of productivity and the contribution of frontier firms in a more granular way. The work focused on the role of innovation ecosystems, international connections, and organisational form/ownership structures in supporting productivity growth.

These industry case studies are an important part of the evidence base for the frontier firms inquiry. This report summarises the findings from the case studies, identifying various opportunities for improving productivity, some industry-specific and some more generic. The Commission's recommendations for addressing these issues are set out in the inquiry report – *New Zealand firms: Reaching for the frontier* (NZPC, 2021).

1.2 How the four industries were selected

The aim of this work was to focus on industries where productivity improvement could help materially "shift the dial" on New Zealand's aggregate productivity performance. To this end, the Commission focused on tradeable industries of significant size, and/or those with high-growth potential (such that they could become significant contributors to the economy in the medium term). The selected industries also needed to span a diversity of firm ownership structures, business models and innovation ecosystems, so that these different approaches could be compared and contrasted.

The four chosen industries were: Dairy, Health Technology (HealthTech), Horticulture (with a focus on kiwifruit and wine) and Software. In addition to meeting the selection criteria, these industries cover two traditional, resource-based industries and two "weightless" industries.[2] Appendix A sets out the 4-digit ANZISC industries that were combined to form each case study. In summary, the four industries comprise the following:

- Dairy – farming and processing;
- HealthTech – medical devices, digital health & IT products, and diagnostics and therapeutics;
- Horticulture – fruit, vegetable and nut production and processing, with a focus on kiwifruit and wine; and
- Software – a subset of the broader information and communication technology (ICT) and digital sectors, comprising Software products (for example, software as a service (SaaS) and web-based applications) and services (for example, database management, system integration and security).

The selection of the case-study industries for research purposes should not be confused with identifying focus areas for innovation policy, which is discussed in Chapter 7 of the inquiry report. Each case-study industry is a possible contender to be an area of focus for innovation policy, but this paper is silent on the matter.

[2] So-called weightless industries have high value-added relative to their "shipping" weight. Software products and services, for instance, are entirely weightless as they are intangible; while some health technologies have a very high ratio of value to weight.

1.3 A mixed-methods approach

The research involved the following methods:

- **Reviewing existing literature, analysis and statistics**, to develop a descriptive narrative of each industry (background and trends) and its innovation ecosystem, key institutions, ownership structures, regulatory framework and labour force.
- **In-depth interviews** with industry stakeholders, including firms, research institutions and universities, industry experts and government agencies.
- **In-house analysis** of productivity trends and characteristics using the firm-level data in the Longitudinal Business Database (LBD), and of relevant questions/modules in the Business Operations Survey (BOS).

1.4 Some definitions

LBD data

The Commission used LBD data that was prepared for productivity analysis by Fabling and Maré (2019). This data excludes very small firms (for example, those with a sole working proprietor or single-employee firms), noting that this excludes many owner-operated start-ups.[3]

The LBD data covers the period 2001–2018. The relatively small size of some of the industry datasets made it difficult to use annual data. Instead, the data was grouped into three time periods: 2001–07, 2008–12 (the period of the Global Financial Crisis) and 2013–18.

Frontier firms in an industry were defined as firms that are most productive, measured by labour productivity. Given the limited size of the datasets (especially for HealthTech), and the need to comply with Stats NZ's confidentiality rules, the firms in each industry were sorted into three groups by labour productivity. The three groups of firms were the bottom 30%, the middle 40% and the top 30%. The top 30% are referred to as frontier firms for the purposes of this analysis (instead of the more usual top 10%) and the bottom 30% as laggard firms.

BOS data

The BOS analysis used the same industry classifications as the LBD analysis. The Commission looked at the most recent available data from the International Engagement module (2015) and the average of available years from the Innovation module (2011, 2013, 2015 and 2017).[4]

National accounts data

The Commission obtained some statistics about the case-study industries from national accounts data produced regularly by Stats NZ. For example, measures of an industry's size include revenue, employment and contribution to Gross Domestic Product (GDP). The last of these is a measure of value-added by all the firms classified as belonging to that industry.

1.5 Analytical limitations

The datasets described above have features that may limit the extent of conclusions that can be drawn from them. For example, the BOS data exclude firms with fewer than the equivalent of six fulltime employees, which means that many of the promising start-ups in the Software and HealthTech industries are not included. In some instances, data for an industry are suppressed for confidentiality due to small numbers of firms, which limits the extent that cross-industry comparisons can be made.

[3] The LBD includes only firms with more than one fulltime equivalent (FTE), and for whom the sum of FTEs and the working proprietor exceeds two.

[4] Data from the 2019 BOS was not available in the Integrated Data Infrastructure (IDI) at the time of writing. Only firms with a "rolling mean employment" of six or more FTEs are included in the BOS.

Another issue affects measurement in the weightless industries: intangible capital – a key feature of these industries – is hard to value and is not well captured in official statistics.

These features mean that results for these industries and comparisons across them should be interpreted with care. For example, industries with a high proportion of young firms that are not yet earning significant profits, but have strong potential for future profits, will have low measured productivity.

It is also important to note that industry GDP figures do not give a comprehensive picture of the total amount of economic activity associated with these industries, as they do not capture upstream and downstream activities that fall in different industries. For example, a lot of inputs to the dairy industry are produced by firms in other industries (such as in transport, fertiliser production and veterinary services).

Part two:

Industry case studies

Part two provides a portrait of each of the case-study industries based on the three methods described in the previous section.

2 Dairy

2.1 Dairy is a large and important industry

Dairy (encompassing on-farm production and processing) has been and remains a very important industry in the New Zealand economy. It earnt over $16 billion in export revenue in the year to June 2019, around 20% of New Zealand's total exports of goods and services. Economic activity in dairy makes up roughly 3.6% of GDP and generated 43 000 jobs at an average annual income of $66 000 per full-time employee (FTE) in 2018 (Stats NZ, 2020b, 2020a).

Dairy is a mature industry that continues to evolve alongside and in response to a changing set of external circumstances. It grew very strongly in the decade up to 2015 (spurred by high world dairy prices), but output has stabilised since then. Dairy exports increased at a 6.0% average annual growth rate over 2001–18, lifting dairy's share of total exports from 14% to 21% over that period. Labour productivity growth in agriculture averaged 1.8% per year from 2010–20, a solid result but with a lot of variation in the yearly growth rate.[5] Over the same time period, average annual labour productivity growth in food, beverage and tobacco manufacturing was negative at -0.5% (Stats NZ, 2021).

The dairy industry consists of two distinct types of businesses: dairy companies that tend to be large, capital-intensive processors of raw milk into a range of products that they then mostly export; and dairy farmers who produce and supply raw milk to the dairy companies.

Using the LBD, the Commission found that average wages are higher in dairy processing than dairy farming (an average over 2013-18 of $86 000 per year in processing against $53 000 in farming). While both processing and farming are capital-intensive activities, labour productivity (that is, the value of output per worker) is significantly higher in dairy farming than processing because of all the land that farmers work with to make them productive.

The growth of dairy over the last two decades has spurred concern because of its negative environmental impacts on the quality of freshwater, emissions of greenhouse gases (GHGs) – mainly methane and nitrous oxide – and on some natural landscapes. Nearly half of New Zealand's total GHG emissions come from agriculture, with around 50% of those from dairy.[6]

2.2 Dairy companies vary in type and performance

Fonterra, a dairy cooperative, is New Zealand's largest company and it processes just over 80% of raw milk produced in this country. It is among the top 10 global dairy companies and is the largest dairy exporter. It has become one of the world's foremost ingredients suppliers to big food manufacturers (Pawson, 2018). Fonterra's global strategy, following its creation in 2001, saw it buying into dairy operations and joint ventures in Australia, South America, Europe and China. Unfortunately, several of these investments worked out badly for Fonterra and it suffered declining earnings, rising debt levels and a loss in owners' wealth of around $4 billion from around 2014 to 2018. In the last three years, under new leadership, Fonterra has retreated from these types of global investments and sold off assets to stabilise its debt position.

New Zealand dairy, as an industry, lost impetus from Fonterra's problems and farmers' apprehension about ever-stricter environmental standards. However, Fonterra's actions to get its financial structure in order (plus recent strength in world prices for dairy commodities) have seen the company return to profit, higher farmgate returns and improved confidence. The cooperative's new direction is a back-to-basics focus on maximising returns from its New Zealand-sourced milk and marketing the quality of that milk. Outputs range from commodity milk powders to value-added speciality ingredients and nutritional products. In its submission to the Commission's frontier firms inquiry, Fonterra accepted that

[5] Agriculture includes sheep and beef farming, horticulture and cropping as well as dairy farming. It does not include dairy processing.

[6] These percentages are based on the standard GWP_{100} metric. They would reduce under metrics that recognised that methane, the main GHG produced by dairy farming, is a relatively short-lived GHG.

future growth in milk supply will be modest at best and that returns must come increasingly from innovation and adding value (Fonterra, 2021).

The creation of such a large and dominant dairy company as Fonterra came directly as a result of the Dairy Industry Restructuring Act, 2001 (DIRA). Proponents of Fonterra argued it needed this scale and scope to become a "national champion" and global player in dairy. At the same time, DIRA abolished the New Zealand Dairy Board (with its single-exporter status) and folded its assets into Fonterra. This effectively deregulated dairy exporting by permitting all dairy processors to sell their products on international markets.

Industry deregulation has stimulated new entrants in dairy processing

The deregulation under DIRA has produced some successful outcomes in that several other dairy processing companies have set up and grown over the past 10–20 years. They have prospered to varying degrees using a variety of approaches and business models (Barry & Pattullo, 2020). The main developments follow below.

- The a2 Milk company exports infant formula milk powder made exclusively from type a2 milk. It has harnessed demand, largely from Asia, for the special properties of a2 milk using clever branding and marketing. Unusually, it has conducted its innovative dairy business without owning any farms, milk tankers or factories. Rather, it contracts out milk supply and processing to farmers and dairy processing companies. By market value, a2 Milk was one of New Zealand's most valuable listed companies until Covid-19 disrupted some of its main routes to market during 2020. The company has cut its growth and profit forecasts and its share price has suffered more than a 50% fall since August 2020. a2 Milk has recently bought a 75% stake in a Southland milk processor – Mataura Valley Milk – so its assets are no longer the purely intangible ones of customer links, brand, IP and research.
- Synlait is the main supplier of a2 milk to the a2 Milk company. It has invested in substantial processing capacity in the South Island and has significant foreign ownership.
- Open Country Dairy (OCD) is majority owned by the Talleys Group and has been successful in manufacturing and exporting low-cost milk powders and cheese. Its strategic strength is as an efficient and low-cost processor and ingredients supplier.
- Miraka is Māori owned and has a strategic partnership with Vinamilk, the largest dairy company in Vietnam. Māori values are integral to Miraka's brand and the company offers another example of dairy innovation. It has a novel product range and pursues a sustainability ethos. For instance. it uses geothermal energy for processing its milk and composts its biological waste for use in its native plant nursery.
- Tatua is small but long-established (1914) dairy cooperative. It earns high rates of return from its innovative and distinctive products, which it sells through supply chains and subsidiaries in Japan, China and the United States. Despite its high profitability, it has not expanded in size and new entrants have not managed to imitate its success. Tatua's experience is instructive. It has evolved a difficult-to-imitate niche of highly specialised nutraceutical and pharmaceutical ingredients that occupy quite specific positions in sophisticated value chains. The relationships and standards required for these value chains take many years to build.
- Westland, also a cooperative, became severely distressed through excessive debt and has been bought by the Chinese company Yili, which also operates other processing plants in New Zealand.

Commodities versus value-added in dairy

The relative merits of manufacturing wholesale dairy ingredients versus branded consumer goods and sophisticated derivatives of milk is a keenly debated topic in the sector. Success and failure in each approach have occurred. Fonterra's attempts to move "up the value chain" have had mixed success, which appears to reflect a combination of factors:

- Milk is a perishable commodity, and the large amount of expensive capital that the cooperative's farmer-owners have got tied up in the form of their farms depends critically on reliable daily collections and good prices for their raw milk.
- A farmer-owner's major asset is their farm, not their shares in Fonterra. Many Fonterra farmers are already moderately to highly leveraged and are therefore reluctant to supply capital beyond what is needed for processing their milk and on-selling it, especially if this involves the higher levels of risk associated with innovative, high value-added new products. At the same time, the farmer-owners are unwilling to cede any control of their cooperative to outside capital.
- Fonterra's legal obligation to accept all new milk, combined with large increases in supply and the highly seasonal pattern of milk supply under New Zealand's pastoral farming conditions, has almost forced the company to invest in the capacity needed simply to process and export milk powder in bulk.
- Investments in offshore dairy operations (both outright ownership and joint ventures) to secure year-round supplies and greater market penetration have proved far more difficult than anticipated, largely owing to differences in language, customs, and business and physical conditions compared to New Zealand.

Fonterra's current retreat to focus on its core business lines (for example, commodities such as milk powders and food-service ingredients sold to other businesses) reflects these factors. How far this proves to be a sustainable and winning strategy is an open question. The challenges that any dairy business strategy must grapple with are set out in sections 2.6 and 2.7.

2.3 Land conversions to dairy have hugely expanded total milk supply

Traditional regions for dairy farming are Waikato, Taranaki and Southland. While these regions have seen a steady expansion of dairy land and herds, large conversions of land in Canterbury and Otago turbocharged milk production from the early 1990s to around 2015. These conversions benefited from economies of scale in both farming and processing, with irrigation an inseparable part of the formula (Pawson, 2018). New Zealand milk supply increased from around 7 billion litres processed in 1990–91 to more than 21 billion litres in 2018–19 (LIC & DairyNZ, 2019).

Other features of the expansion in dairy production are relevant to innovation, productivity and environmental impacts.

- An increasing proportion of milk is coming from large corporate dairy farms, with a corresponding reduction from traditional family-owned dairy farms. Industry participants told the Commission that while a bell curve of performance exists in dairy farming, the laggards tend to come from the smaller, family-owned operations.
- Productivity per hectare greatly increased following the widespread availability of urea after the construction of the ammonia urea plant at Kapuni in the 1980s. The new pasture system also increased the need for irrigation. Between 1992 and 2002 dairy cows per hectare rose by 19%, milk solids per hectare by over 34% and urea fertiliser use per hectare by more than 162%, although from a low base (Parliamentary Commissioner for the Environment, 2004).
- While increases in output per hectare and per cow may look impressive, increased inputs of fertiliser and supplementary feeds sourced off-farm contributed significantly to these increases. Feeds include maize and palm kernel meal (sourced from countries like Indonesia and Malaysia). Imports of palm kernel began in 2003 and rose rapidly to reach 2.4 million tonnes in 2014 (Pawson, 2018). Awareness of, and protests about, the negative environmental impacts of the palm kernel industry in the source countries has led Fonterra to discourage its use among its farmers.
- True measures of productivity should account for all inputs, including negative environmental impacts. Per hectare measures can give a distorted picture because they ignore the costs not only

of fertiliser and other inputs used to boost output, but also of negative downstream environmental impacts.

- Some farmers and researchers have demonstrated that farm profitability can be as good or better with a more conservative model of lower stocking rates, fewer inputs and better-fed, better-bred and healthier cows. Other benefits are fewer GHG emissions and reduced nitrogen leaching to waterways (de Klein & Dynes, 2017).

2.4 Recent amendments to DIRA are concerning

As noted, DIRA has been a major influence on the structure and dynamics of the dairy sector. As well as creating Fonterra as the super-dominant player in the New Zealand dairy industry, DIRA imposed an obligation on it to accept all milk offered to it by farmers prepared to buy Fonterra shares. This was designed to create competitive pressure on Fonterra by allowing farmers to exit to supply new processor entrants without the risk of them burning their bridges if the new business failed. Again, as noted, this obligation has played a valuable role in supporting the emergence of new players in dairy processing. Fonterra's market share has reduced from over 95% at its formation in 2002 to just over 80% in 2020 (Barry & Pattullo, 2020; NZPC, 2021).

Recent amendments to DIRA have reduced Fonterra's obligation to accept milk. One amendment means that it may refuse supply from new land conversions. A strong environmental logic exists for this amendment. This obligation contributed significantly to the huge expansion in milk supply and to Fonterra's need to invest in expensive processing capacity, with its high fossil-energy inputs and bias towards commodity production of bulk milk powder. Fonterra will now be able to refuse such new supply or make it subject to environmental conditions.

However, another amendment – promoted by Fonterra – means that it will also not be obliged to take back any farmers who had left it to supply another milk company. This amendment is due to come into force in June 2023. This ending of free entry and exit of existing farmer-owners on existing dairy land creates a significant barrier to new dairy processing firms obtaining enough new supply to be viable. It gives Fonterra a strong hold over its existing suppliers, and risks perpetuating the company's still strong dominance and inhibiting ongoing dynamic efficiency and innovation in the sector. The Commission has made a recommendation on this issue in Chapter 10 of its frontier firms inquiry report.

2.5 The dairy innovation ecosystem is complex and diverse

The dairy innovation ecosystem has diverse components:

- The main industry body for dairy farmers – DairyNZ – collects a levy from farmers that it spends on R&D to achieve industry-good improvements in farming, farming systems, climate resilience and biosecurity. The levy also funds diffusion activities (such as demonstrations, field days, discussion groups and workshops), and information tools and templates. The levy collects around $67 million each year.

- The Government is a major indirect funder of R&D carried out by organisations such as CRIs (AgResearch and Landcare Research), Massey and Lincoln Universities and several CoREs (the Riddet Institute, Food for Future Consumers, Bio Protection and Designing Future Productive Landscapes). A current national science challenge is relevant to innovation in the dairy sector. This is "High-value nutrition" aimed at "the transformation of New Zealand's food and beverage industry to become an exporter of high-value foods with scientifically proven health benefits" (MBIE, 2020b).

- Massey and Lincoln Universities offer specialist agricultural training and qualifications (sub-degree, degree and postgraduate) and operate model farms. A staff member at Lincoln's demonstration farm explained that "[it's] leading transformation through demonstration – to facilitate sustainable, feasible and bankable solutions. The small and medium enterprises operating in the primary industries need a pre-investment proof of concept."

- The Ministry for Primary Industries administers co-funding programmes (such as the Primary Growth Partnership (PGP) and Sustainable Food and Fibre Futures (SFF Futures)). The latter has superseded the former despite positive independent evaluations of the PGP. SFF Futures has government funding of around $40 million a year and aims to help all types of food and other primary sector producers (not just dairy) move towards greater value-added and sustainability. Independent evaluations are planned for some but not all projects.
- In the private sector, LIC (formerly the Livestock Improvement Corporation) is a cooperative that plays a major role in improved animal genetics and breeding, artificial insemination and other on-farm technologies. Private sector businesses (such as Fonterra and Tatua) undertake proprietary R&D. Fonterra operates its Fonterra Research and Development Centre (FRDC) in Palmerston North. The centre's website notes that the FRDC "is one of the largest of its kind in the world, with around 250 scientific and technical staff… The centre represents a significant investment in innovation, driving scientifically supported benefits from dairy to meet nutritional needs."[7]
- Agritech in dairy is a surprisingly small sector given the importance of dairy in New Zealand's economy.[8] Along with LIC, the large and long-established Gallagher Group Ltd is an anchor firm. It invented electric fencing and has diversified into other areas within and outside of farming (such as security and access systems). Waikato Milking Systems (WMS) is another significant dairy technology company in which Ngai Tahu Holding Group's made a major investment in 2014. WMS is well aligned with Ngai Tahu's values of helping to improve productivity and long-term sustainability in the agricultural sector. WMS has featured in the Technology Investment Network's (TIN) top 50 revenue-generating companies. Agritech also features innovative start-up companies (such as Halter which makes electronic collars for cows to control their movements and monitor their health).

The significant size and complexity of the dairy innovation ecosystem is to be expected given the long history and importance of New Zealand's dairy industry. The system has certainly been, and remains, an area of focus for government attention and investment, despite the lack of any deliberate policy choice to make it an area of focus. Including and beyond dairy, a food and beverage innovation cluster has developed in Palmerston North (see Box 1).

Box 1 **A geographic cluster of food and beverage innovation in Palmerston North**

Palmerston North has a substantial geographic cluster of research institutions, including the Riddet Institute, AgResearch, Plant & Food Research, Massey University's School of Food and Advanced Technology and the New Zealand Food Safety Science and Research Centre. It also has the R&D centres of dairy firms (such as Fonterra and Synlait and the headquarters of FoodHQ – a food research and innovation hub that is an open collaborative partnership with partners from CRIs, universities, Economic Development Agencies and Industry Training Organisations). A joint AgResearch, Massey University and Riddet Institute building opened on the Massey campus in 2020. This has enabled all AgResearch's food-focused researchers from across New Zealand to be co-located with Massey and Riddet Institute staff.

The Finistere Aotearoa Fund - a subsidiary of Silicon Valley venture capital fund Finistere Ventures – is also located in Palmerston North on the Massey campus, as are some of the early-stage agritech companies in which it has invested such as BioLumic.

Inquiry participants described Massey University's critical anchoring role, providing a strong knowledge base and a magnet for students. However, participants identified opportunities for greater integration and connectivity across the food and beverage innovation ecosystem, and a need for greater critical mass and deep expertise.

[7] Fonterra's current range of innovative products includes a patented mozzarella-type cheese with advanced properties, specialised creams, milk protein concentrates for specialised nutritional needs, and a technique of milk fingerprinting to analyse milk quality and trace provenance (Fonterra, 2021).

[8] The number of firms in the Agritech section of the TIN 200 index is 17, of which eight relate to dairy. Healthcare has 22 firms, Heavy Manufacturing 19 and Software Solutions 37 (TIN, 2020b).

Some pointed to Foodvalley in the Netherlands, where the top-rated Wageningen University and Research is located, as an example of how coordinated investment at scale can help develop world-class capabilities and facilities (see Box 2).

The weakness in New Zealand's dairy ecosystem can manifest itself in multiple, and sometimes competing, small-scale research entities and projects that fail to make connections or achieve critical mass. Some interviewees attributed the fragmentation, lack of dynamism and aversion to radical innovation to each individual organisation's patch protection and focus on preserving and/or increasing funding streams.

Box 2 **The agricultural innovation ecosystem in The Netherlands**

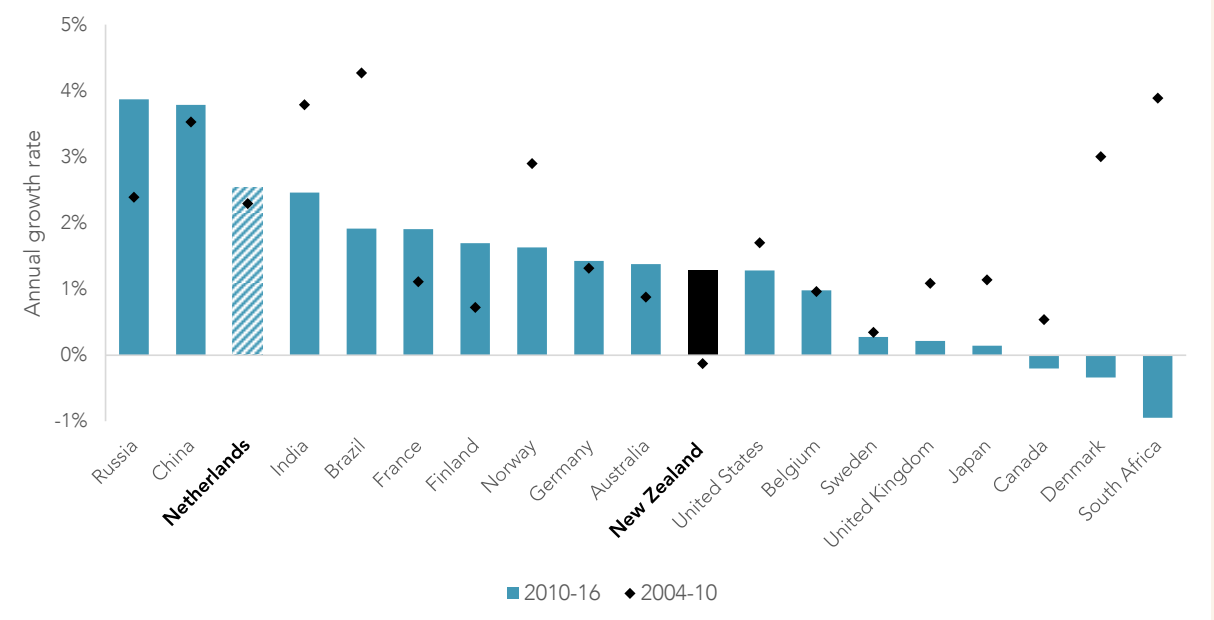
The Netherlands is a small advanced economy (SAE) with high productivity and average income. Agriculture and horticulture are substantial, knowledge-intensive industries. The main on-farm activities are grassland and intensive livestock farming including dairy (54% of agricultural land use in 2013), cropping (41%), and open-field and greenhouse horticulture (5.5%). Including the processing, manufacturing and distribution activities in agri-food, plus on-farm activities, the sector comprises around 10% of GDP and employment.

Innovation and exporting are prominent drivers of strong productivity performance in the Netherlands in agriculture and horticulture. Export performance in turn is driven by continuous development and/or adoption of technological, organisational, product and marketing innovations, which help Dutch farmers and processors to maintain a competitive edge in EU and global markets. As shown in Figure 2.1, from 2010–2016, multifactor productivity growth in agriculture in the Netherlands averaged 2.5% a year compared to 1.3% a year in New Zealand.[9]

The general policy environment is favourable to innovation because of the ease of doing business, well-functioning and competitive markets, openness to trade and investment, high-quality infrastructure, and high-quality education systems responsive to business demand in providing a well-educated and skilled labour force.

Figure 2.1 Multifactor productivity growth in primary agriculture, 2004–16

[9] Multifactor productivity growth represents the increase in added value that cannot be attributed to measured inputs to a production process. It is the contribution to value from new technologies, advances in knowledge, scale economies, and improvements in management, worker skills or production processes.



Source: U.S. Department of Agriculture (2019).

Other positive features more specific to the agricultural innovation system include:

- strong investment over the long term including in R&D;
- widespread and continuous adoption of innovation based on a continuous process of rationalisation, consolidation, mechanisation and specialisation;
- good collaboration between government, research, education and industry, making innovations relevant and widely adopted both on-farm and in agri-food business;
- high participation in international collaborative efforts; and
- strong industry input into public-private partnerships that are key in setting research and teaching priorities through the Netherlands Top Sectors policy (a form of focused innovation policy). Two of the Top Sectors are Agri-Food and Horticulture and Propagation Materials.

Wageningen University and Research Centre and "Foodvalley"

At the centre of innovative agriculture and agribusiness in the Netherlands is Wageningen University and Research (WUR) and an associated business cluster known as "Foodvalley". WUR is world-leading (ranked in the top five institutions) in agricultural sciences (in both teaching and research). It supports multi-disciplinary approaches (for example, sciences, economics, agricultural and natural resources), attracts foreign staff and students, and participates in international networks.

Wageningen was formed in 1997 to rationalise overlaps and unnecessary competition between Wageningen University and several government-owned Agricultural Research Institutes. These institutes are now part of the WUR complex and specialise in areas (such as livestock research, plant research, food safety and agricultural economics research).

Foodvalley NL is a public-private cluster/network of food companies and research companies and institutes launched in 2004. Overall, it includes 15 000 food scientists and engineers in a radius of 50 km from Wageningen. The aim is to create conditions for food manufacturers and knowledge institutes to work together in developing innovative food concepts.

Illustrating the Netherlands global status in food innovation, 12 out of the global top 40 food and beverage companies have R&D facilities located there, including Danone and Unilever.

Environmental concerns

Agriculture, including dairy, faces environmental challenges and other risks. The Government is increasing pressure to tackle them through a variety of goal-setting, regulatory, research and financial incentive initiatives.

Agricultural policy now includes a long-term vision for the entire agri-food sector, one that is environmentally sustainable while maintaining productivity growth.

Source: OECD (2015).

On knowledge diffusion, some industry stakeholders regretted the demise of the pre-1990s farm advisory services to enable or persuade more farmers to adopt new technologies and business models. They observed that a significant proportion of farmers are resistant to investing in change from volume to value.

The innovation ecosystem appears to lack an overall direction and vision. While diversity and freedom to pursue different directions are important for innovation, big mission-critical challenges (such as reducing GHG emissions from dairy, reducing the amounts of nitrates leaching into waterways and even attending to the threat posed by synthetic milk) do not receive the funding or effort commensurate with their importance (NZPC, 2018). The Primary Sector Council's *Fit for a better world* vision is an example of how a bold strategic direction could inform and influence the dairy innovation ecosystem (Primary Sector Council, 2020).

These weaknesses and the Netherlands example suggest the need for a less fragmented, more cohesive innovation system, and better ways to disseminate new technologies and farming methods to improve uptake.

2.6 A new approach is needed

With exceptions like Tatua, a2 Milk and more recently Miraka, the predominant trend in dairy has been to strive for greater volumes of milk production and processing it into bulk ingredients for sale at world prices. One argument for volume growth is that dairy prices will be buoyed by international demand on the back of the rising incomes of a growing Asian middle class. The Covid-19 pandemic has raised some questions about international supply chains, yet dairy prices and exports have remained surprisingly solid to date. Indeed, prices for whole milk powder in the global dairy auction rose sharply in early March 2021, partly due to the authorities telling the huge Chinese population to drink more milk to stay healthy.

However, over time it is likely that supply from lower-cost producers will grow in response to buoyant dairy prices and this will dampen the returns to business-as-usual dairy farming in New Zealand. Many dairy farmers are already under pressure from high land prices and debt levels. Sliding into a commodity trap would not be a good outcome for them.

Neither is a strategy of ever greater dairy production within New Zealand, even with ongoing cost efficiencies, a sustainable option. As widely, but not universally, accepted, dairy is reaching its environmental limits. Its "social licence" is becoming frayed. Many farmers understand this and are making commendable progress in finding and implementing more sustainable methods. Yet, the previous zeitgeist in dairy to maximise output per cow and/or per hectare still exerts a strong influence and will take time and deliberate steps to shift.

An unhelpful consequence is that these crude metrics can drive land values, which incentivises farmers who own their farms to pursue them even at the cost of neglecting the mounting monetary and environmental costs of evermore intensive use of inputs. As noted above, it has been shown that farming less intensively may yield lower outputs but higher profits (de Klein & Dynes, 2017). This

suggests a flawed focus on maximising average yields, rather than expanding output, but only if marginal revenue exceeds marginal cost.

In one interview, a stakeholder (experienced in dairy farming and processing) noted the unsustainability of some rural land prices. In his appraisal, prices being paid were not consistent with an adequate return to any form of farming suited to the land. Instead, the behaviour pointed to buyers' lack of realism, or interest in earning capital gains from further increases in land values.

Future potential for healthy growth in the value of Dairy likely lies in moves towards branded and distinctive products that New Zealand farmers and companies produce in environmentally sustainable ways. The industry needs to better market New Zealand and/or company brands based on difficult-to-imitate features. This can create an enduring competitive advantage and earn superior returns as gold kiwifruit and the premium end of wine have achieved (see section 4).

2.7 Making progress on meeting the dairy industry's challenges

Fonterra's new direction

Fonterra's new direction under new leadership is showing not only better financial returns, but also acceptance of the need for a shift to greater innovation to produce value rather than volume in the face of "peak cow". Fonterra is also working to bring its farmer suppliers up to minimum standards in environmental performance and animal welfare (Fonterra, 2021).

As noted, the nature of Fonterra's relationship to farmer-owners is likely to keep its innovation within quite narrow risk limits. Fonterra farmer-owners continue to exert strong pressure to retain its cooperative structure, yet this is likely to come with two continuing problems:

- Lack of access to capital for investment in the assets needed for expansion and to produce products that have complexity and/or differentiation (C & D products).
- A conservative mindset that is resistant to major innovation and risk taking.

According to Alex Duncan (who formerly held senior corporate finance roles at Fonterra), Fonterra's problems have arisen largely from misguided efforts to push the cooperative model into C & D products closer to the customer (a "grass to glass" strategy) for which it is unsuited.

> Farmers never really bought the story. We can discern that, not from what they said, but by how they behaved, which is always more revealing. They rejected these innovations at every opportunity. To see this playing out, let's consider the story of how Fonterra arrived at 2019.
>
> From the dairy industry's earliest days, cooperatives were established to ensure that farmers' perishable milk would be processed into a durable form that could be sold at a fair price. Farmers were able to raise debt to help finance their new factories by subordinating their milk cheques to debt claims.
>
> Fonterra shareholders… continue to value control over the facilities on which they rely to process milk into durable products for sale internationally. Their financial exposure to their farms dwarfs their investment in Fonterra.
>
> But if Fonterra messes up, it is shareholders who have to stand behind its debt.
>
> They therefore have a strong motivation for the co-operative to be prudent and excel at the basics of processing milk into stable products.
>
> Consequently, since Fonterra's formation, its shareholders have been reluctant to provide capital to support an expansive downstream strategy. (Duncan, 2019, p. 2)

To resolve this tension, Duncan's view is that Fonterra should simplify itself by focusing on its core ingredients business. The close connection with its farmers ensures a tight vertically integrated upstream supply system. Its own high-quality processing assets can flex the ingredient product mix in response to market volatility. As for its C & D assets:

> The residual downstream and consumer business assets should be sold in a contestable process. A contractual link may remain for Fonterra to supply dairy products to the spun-out entities.
>
> Fonterra would also partner with other New Zealand downstream dairy players, rather than competing with them. Offshore ingredients assets would be retained only if they serve the refreshed upstream strategy of the business.
>
> Fonterra shareholders who wish to invest downstream could continue to do so by holding a stake in the spun-off businesses. But no one will be forced to do so, as they are currently. (Duncan, 2019)

The direction that the new leadership at Fonterra are taking has some elements of this suggested strategy. Yet because this strategy relies on other dairy players making the innovation running outside the Fonterra "core", it emphasises the desirability of encouraging the emergence of new players. This, in turn, underlines the importance of retaining Fonterra's obligation under DIRA to take back existing suppliers who have left to supply a new entrant and wish to return to Fonterra.

A possible catchment-wide approach

A potential approach mentioned by some stakeholders to achieving both higher returns and incomes and better environmental outcomes in New Zealand's primary sector is for farmers and other land users in the major river catchments to do a better job of integrating their land use recognising catchment-wide effects and interdependencies. To succeed in this would require collective action and be a difficult challenge. Yet, it has the potential to yield not only a much-improved natural environment, but distinctive and valuable regional products and branding.

The role of government

Government has an important role in helping the dairy industry towards a sustainable and prosperous future. This role should be a convening and supporting one rather than directive. Ideas and initiatives are best when they are largely industry-led, yet facilitated and enabled by government. Government support is key in areas (such as international representation, negotiation of trading rules, bringing parties together, investment in research, investment in sector skills, removing barriers to the flow of resources to higher value uses, and designing and implementing regulations) that incentivise desirable change in safe, fair and efficient ways.

The dairy industry suffers from skill shortages in several areas. To overcome these requires government and industry to work together:

- The attractiveness and quality of training for young people entering the dairy workforce needs improvement.
- The dairy sector relies to a considerable extent on migrant labour (around 20%) to fill permanent jobs that locals are not willing to do at wages currently on offer. This is a challenge for the industry because it suggests the lack of a healthy pipeline of trained young people willing to enter the industry and/or that pay and conditions do not match those on offer in other industries.
- The ready availability of imported workers under current migration policy settings (at least up until Covid-19 led to the closure of New Zealand's border) is a disincentive to investment in automation and other labour-saving, productivity-raising techniques in Horticulture (section 4), and to a lesser extent in dairy.

Innovative agritech has played a crucial role in the history of the New Zealand dairy sector. However, more is needed, together with more effective diffusion and adoption to make dairy a high-performing industry for the future. Digital, AI, biotech and sophisticated engineering tools, and combinations of these, have huge potential. One of the Government's industry transformation plans (ITPs) is in agritech, yet implementation and realistic resourcing of the plan have advanced little to date. Chapters 7 and 8 of the Commission's frontier firms report recommend how this could be done.

3 HealthTech

Health Technology (HealthTech) is the largest subsector of New Zealand's wider 'technology' sector. It can itself be broken down into three main sub-parts, each anchored by one of New Zealand's three largest HealthTech firms:

- Medical devices: including "point of care" devices for diagnostics, treatment, monitoring and rehabilitation. In 2019, medical device companies made up about 23% of the companies in the HealthTech sector and generated around two-thirds of the revenue (TIN, 2020a). This is due to the dominance of Fisher & Paykel Healthcare, which alone contributed 57% of HealthTech revenue in 2020 with their respiratory devices (this figure is likely to have grown in 2021 due to the impacts of Covid-19) (TIN, 2020b).
- Digital Health and IT products: including a wide range of Software and tools for electronic automation of processes like health logistics, inventory, keeping and sharing health records. It also includes Software and web-based tools for employee, payroll, rostering and workflow processing for the healthcare sector, and platforms for supporting telehealth. In 2019, Digital Health & IT companies made up about half the companies in the sector, yet only generated around 13% of the revenue. The largest company in the subsector is Orion Health, which generated over 6% of the total HealthTech revenue in 2019, about half of the revenue for this subsector.
- Diagnostics and therapeutics (D&T): including pharmaceutical products and other medicines for treatment and prevention, as well as immune therapies and biotech products. D&T companies make up about 27% of the companies in the sector and generate around 25% of the sector's revenue. The largest player is Douglas Pharmaceuticals, which generated almost 13% of total HealthTech revenue in 2019.

The lines between these sub-parts is blurring as Software becomes increasingly integrated into both diagnostics and medical devices. HealthTech is becoming more reliant on data, causing a convergence of technology across the industry. This is a good example of the synergies rising from industries with a high component of intangible capital (see section 5).

Many of New Zealand's HealthTech firm, including some rapidly growing smaller ones, appear to be operating at or near the global productivity frontier. They support learning and diffusion of ideas and knowledge, for example, as skilled staff move from the anchor firms into smaller firms.

3.1 A "born global" industry

The industry is growing strongly

The HealthTech industry generated $2.1 billion in revenue in 2020. Revenue has grown around 9.7% a year over the last five years. Most of that growth has come from medical devices and D&T. Digital Health & IT revenue growth rates are difficult to calculate on a consistent basis, as Orion Health has had a challenging few years and sold part of its business to HG Capital.

According to the TIN, the industry employed 8 213 people in 2020. This figure includes staff employed overseas, with just over half based in New Zealand. Stats NZ recorded total employment at 6 100 in 2019. As with revenue, employment is dominated by Fisher & Paykel Healthcare. The average size of HealthTech firms (in terms of employment) is relatively high.

Industry stakeholders are bullish about the scope for continued growth in the HealthTech industry. Healthcare spending in developed countries has grown faster than income since the Second World War Two and this trend looks set to continue. It seems likely there will continue to be demand for new technology that can improve health outcomes. However, as cost pressures continue to rise, demand will also build for technology that can improve the productivity of the wider health system. For example, tools that can save valuable clinician time or help people manage their own health better.

Five companies employ more than 200 people and 22 companies are in the TIN top-200 list (TIN200). According to Stats NZ, there are almost 390 firms in the industry, but in 2017 only 93 firms met the Commission's threshold for inclusion in its analysis. The number of firms over the threshold has grown 40% from 2001. This low number of firms makes the results of survey data very tentative for this industry.

Many HealthTech firms have an international outlook from day one

HealthTech firms tend to be globally oriented from day one, as the local market is too small to support meaningful scale. Industry stakeholders report that even the youngest companies that are not yet exporting intend to do so as soon as their products are proven in trials, further developed, or accepted by international regulators. Some Digital Health & IT firms are sustainable operating only in New Zealand, but most report they intend to export regardless.

HealthTech firms are highly likely to export, with around 80% of firms reporting they are exporting. Exports are growing fastest (see Figure 6.2) and HealthTech firms have the highest proportion of revenue coming from exports of all the case-study industries (almost 90% and rising). HealthTech firms also had the highest concentration of exports in its frontier firms. One-third of HealthTech firms have overseas offices. North America is the largest market, making up almost two-fifths of the total revenue, although Asia is growing fastest with a 15% increase in 2019 (TIN, 2020a). In the BOS, firms in this industry reported that the exchange rate was the biggest issue they faced in exporting, followed by exchange rate volatility (see Figure 6.5).

Frontier firms in this sector are more likely to export, and a larger proportion of their revenue comes from exports compared to non-frontier firms. The fixed costs associated with accessing overseas markets, particularly regulatory requirements, may be one reason why frontier firms in this industry are much larger in terms of capital investment and employment (see section 6.1). Other drivers of this could be the fixed costs associated with innovation and R&D.

Productivity

Labour productivity in HealthTech is surprisingly low compared to Dairy and Horticulure, especially given the relatively high wages in the sector. As discussed in section 6, this likely reflects the very high amounts of land, equipment and other capital assets that make labour productive in those other two industries.

Wages in HealthTech are higher than average and growing more quickly than both revenue and employee numbers. This indicates high value-added per employee. HealthTech companies are more profitable on average than TIN200 companies from other sectors, and revenue generated per employee in the sector is $255 000 (TIN, 2020a).

Generally, the reallocation of resources from non-frontier firms to frontier firms seems to be working well within the sector. The bottom third of firms have on average 36% of the productivity (added value per FTE) of the top third. LBD data indicate that both labour and capital seem to be flowing relatively freely from poorer performing firms to more productive ones, at least compared to the other industry case-studies. As a result, frontier firms are larger and growing faster than the rest of the industry.

3.2 A complex but cohesive innovation ecosystem

There are many world-class clinicians active in product and IT innovation within HealthTech in New Zealand, and the research on underpinning science is extensive and internationally recognised. As an indication of this strength, HealthTech firms spent $226 million on R&D in 2019, around 12% of their total revenue.

There are many players in the HealthTech ecosystem

Despite the industry being relatively small in size, the HealthTech innovation ecosystem is complex. Many large, publicly funded organisations are involved in both health research and delivery. They have varying levels of interest in the development of a vibrant HealthTech industry.

In addition to the companies discussed above the HealthTech ecosystem comprises the following:

- Four industry groups that largely correspond to the subsectors (Consortium for Medical Device Technologies and New Zealand Health IT (NZHIT)), but in some cases include importers as well as exporters (Medical Technology Association of New Zealand and Medicines New Zealand). These industry groups lobby on behalf of their members and provide networking, information and training.
- Other independent membership organisations that influence the creation and uptake of health technology such as GPNZ (general practitioners), Health Informatics NZ, New Zealanders for Health Research and New Zealand Association of Clinical Research.
- A regulatory body (Medsafe) that oversees the safety of medicines and medical devices, while the Best Practice Advocacy Centre advocates for the uptake of best practice.
- 20 DHBs (the current Government has pledged to reduce the number to 8–12), 30 Primary Health Organisations (covering primary healthcare) and many private and charitable healthcare deliverers (Whanau Ora deliverers, private hospitals, private practitioners, ambulance services, Plunket, retirement homes and hospices). There are also some separate health funders (such as ACC, PHARMAC) and insurers (such as Southern Cross Healthcare).
- Two universities with medical schools (Auckland and Otago). All eight universities are engaged with HealthTech research in some form, some with multiple departments involved in different aspects of research. Otago Polytechnic and Unitec are also involved.
- Three CoREs that are active in fundamental health research (Maurice Wilkins, Brain Research New Zealand and MedTech), and three that deal with research areas and technologies that can impact HealthTech (Te Pūnaha Matatini, the MacDiarmid Institute for Advanced Materials and Nanotechnology and the Dodd-Walls Centre for Photonic and Quantum Technologies).
- Publicly funded assistance for HealthTech companies through R&D tax credits, and the services of the National Health Innovation Hub (hosted by Canterbury DHB), local body economic development units, NZTE, Kiwinet, UniServices and Callaghan Innovation (including the HealthTech Activator, which helps to connect different players within the industry and to commercialise research).
- Government assistance for HealthTech research through many different research funds. Health research receives money from generic funds (such as the Performance-Based Research Fund, the PreSeed Accelerator Fund and the Marsden and Strategic Science Investment Fund). There are also specialised funds with a particular focus on the health sector, including the Health Research Council and four National Science Challenges: A Better Start (early childhood outcomes such as reducing obesity); Ageing Well (enhancing the independence of the elderly); Healthier Lives (reducing the burden of disease); and High-value Nutrition (becoming an exporter of high-value foods with proven health benefits).

Coordination is required to encourage collaboration

Industry stakeholders reported that close links exist between companies, CoREs, other universities and research institutes, health providers and government agencies that are involved with R&D and commercialisation. This is backed up by the BOS data, which shows HealthTech get a lot of their innovative ideas from CRIs, universities and polytechs (see Figure 6.7).

High levels of collaboration may simply be a function of the industry's small size. They may also be a result of the large numbers of people with postgraduate qualifications within the sector, resulting in strong links between universities and businesses. The MedTech CoRE also appears to have played an important role in encouraging collaboration and nurturing an active innovation ecosystem. This 'connector' role helped the MedTech CoRE spin out two to three new companies each year between 2015–19, creating 76 new jobs (Consortium for Medical Device Technologies, 2021, p. 4). Tertiary

Education Commission funding for the MedTech CoRE ends in 2021. The MedTech team is now involved in Callaghan's HealthTech Activator, which has a similar purpose but significantly less funding.

The industry is geographically concentrated in Auckland. Over half of the companies are located there, including the big three. Some commentators believe scope exists for an 'Innovation Park' to allow HealthTech companies to co-locate, along with researchers. They argue that bringing together the collective expertise of Auckland-based companies, DHBs, research institutes and industry bodies could improve coordination, harness the full potential of spillovers (section 5.2), boost sector growth and help establish the city as an important world player in this field. The resulting agglomeration effect would in turn attract further investment.

New Zealand investment in health research is average

Industry stakeholders told the Commission that New Zealand health scientists are well regarded internationally, and many international collaborations are occurring, including through CoREs, other research institutions and firms.

This partly reflects the funding that goes into health research. For example, the Health Research Council invests $117 million per year, and more than $18 million per annum of the National Science Challenges budget goes into health research.

The submission from New Zealanders for Health Research to the inquiry includes some figures on total Health R&D spending. Based on their figures, New Zealand spends a total of about half a billion dollars, or 0.16% of GDP, on Health R&D (New Zealanders for Health Research, 2021, p. 6). Overseas comparisons are notoriously tricky, but according to WHO data the high-income country weighted mean for Health R&D is 0.19% of GDP and the median value is 0.10% of GDP (World Health Organisation, 2020). This suggests that New Zealand's Health R&D spending is within the bounds of what would be expected for high-income countries.

Yet comparisons with other SAEs are striking and show what is possible when a sector is made a priority for focused innovation policy. The Netherlands Health R&D is 0.33% of GDP and Singapore's is 0.40% – both more than double New Zealand's investment. Denmark's investment is even higher at 0.93% of GDP – almost six times this country's investment. Note that all these countries have focused innovation policies centred on aspects of healthcare. These figures are also expressed as a proportion of income, so given that these countries have higher average incomes than New Zealand, their per capita research spend will be even higher.

This higher level of investment in part reflects much larger HealthTech industries in those countries. For example, Denmark has a large and successful pharmaceutical sector and their HealthTech export revenues are about 12 times New Zealand's. Nonetheless, public funding in these countries has rallied behind private sector success and invested to help grow the innovation ecosystem. This government response may, in turn, have contributed to the industry's success. This illustrates the kind of investment possible when SAEs undertake focused innovation policy.

Industry stakeholders questioned whether research gets too much emphasis and commercialisation not enough, a common theme across the case study interviews. The major barrier to commercialisation seems to be the reluctant role of the DHBs in the innovation ecosystem, as the next section explores.

DHBs are focused on other things besides innovation

DHBs are hugely important organisations to HealthTech firms. They are the major deliverers of healthcare in the country, so their cooperation is needed to help develop and trial innovative new products, and to buy and use those products when developed. Yet industry stakeholders reported that only two DHBs generally supported and fostered innovative HealthTech products and firms. As noted below, DHBs are changing their purchasing rules, but the way products are developed and trialled are likely to remain a problem for HealthTech firms.

Some healthcare purchasers are wary of new technology for understandable reasons. Generally speaking, new technology in healthcare improves patient outcomes, but tends to push up costs

because it results in patients living longer and therefore incurring greater healthcare costs in the future. Some large companies also use trials as a form of marketing, so it is understandable for purchasers to have a degree of scepticism.

Other problems arise from the incentives on DHBs and the way the health system is organised. Most DHBs are stretched for resources, so they tend to focus their resources on serving patients right now rather than thinking long term. DHBs operate in a highly political environment, with elected Ministers, elected boards and very vocal and influential staff. As a result, there is a strong bias against risks and towards continuing the status quo. When considering the costs and benefits of new technologies, internal costs are given greater prominence than external ones such as patient travel time and cost (see Box 3).

In this context there is a natural bias against innovation and new technology. Incremental innovation within current processes is relatively straightforward as it generates immediate benefits. Disruptive or step-change innovation, on the other hand, often involves changing procedures and clinical pathways. This creates short-term, one-off costs and risks, putting many DHBs off.

Small firms often find DHBs difficult to deal with. There are 20 DHBs, each operating independently. Their culture and procurement processes vary, so firms need to engage with each one separately and differently. Procurement processes tend to be conservative, favouring larger suppliers.

These issues were raised in 2011 during a review of clinical trials and innovation by the Health Select Committee. The National-led Government at the time responded (New Zealand Government, 2011), but the issues persisted. The issues were tackled again in Actions Six and Ten of the Health Research Strategy 2017-2027 (Ministry of Health & MBIE, 2017). However, the implementation of this strategy has been criticised as slow, poorly coordinated, lacking in resources and lacking transparency in governance (New Zealanders for Health Research, 2021). Despite repeated diagnosis over a decade, the problems remain.

As a result of all these problems, innovative HealthTech companies are forced to rely on personal networks or turn to the more innovative DHBs (Canterbury and Waitematā) to trial innovative new technologies. Canterbury DHB runs the Health Innovation Hub on behalf of the public health sector. The Hub works with innovators and the rest of the DHBs to develop new products and services with commercial potential. The goal is to demonstrate that innovation offers DHBs a return over time and is worth the investment.

Industry stakeholders feel that for the HealthTech industry to achieve its potential, and for the health system to reap the full benefits of the country's research, DHBs must have the capability and incentives to participate in the innovation ecosystem. For example, section 28 of the Public Health and Disability Act 2000 prevents DHBs from holding shares in joint ventures without getting consent from the Minister. This adds considerable compliance cost to the simplest way for DHBs, including Canterbury DHB and the Health Innovation Hub, to get rewarded for the effort of being involved with trials. This may be the reason why clinical trial numbers have been static since 2008 despite the growth of the HealthTech industry (New Zealanders for Health Research, 2021). Several stakeholders called for a coherent innovation strategy that gave a clear mandate and financial incentives for DHBs to collaborate with HealthTech firms.

Box 3 **ARANZ Medical**

ARANZ Medical Ltd is a healthcare informatics company focused on innovative medical imaging and data-capture devices, and analysis software. Its primary focus is wound care.

The standard medical model is to have regular check-ups in person with doctors, often in specialised clinics, monitoring the progress of wound healing. Information gathering is time-consuming and can be inaccurate. Sometimes patients must travel a long way for these check-ups. ARANZ Medical looks to disrupt this model by allowing patients to be seen in the home or to visit local centres to have a high-definition photo taken of the wound. Its software can accurately measure and track the progress of wounds, allowing escalation of patients with potential problems to their doctor.

This new approach has the potential to improve outcomes and save considerable costs, both in staff time and patient inconvenience. Particularly with diabetes on the rise, poorly managed wounds can quickly escalate into amputations.

ARANZ had real problems getting this innovation trialled and rolled out in New Zealand. Their new way of operating was simply too disruptive to the existing model of delivery in DHBs. New processes would need to be created, IT system changes implemented and clinicians trained. Another big problem was that ARANZ could not find information on how much wound care costs in New Zealand, so it was difficult to build a business case around how much money could be saved.

ARANZ faced the problem that the one-off costs of disruption were clear to DHBs, but the benefits were uncertain given it was an unproven technology. As a result, DHBs were unwilling to take the risk and ARANZ had to go overseas to trial and market its product. It found much greater willingness in the United States to trial and roll out its innovation, and its biggest customer is now the United States Department of Veteran's Affairs. ARANZ is the provider of their "tele-wound" solution.

Now that the approach is running successfully overseas, it is slowly starting to be accepted by the New Zealand health system. The business case is easier to make for DHBs as the model is better developed, proven and more cost-effective overall. The risk is that in the meantime New Zealand could have lost this promising and innovative company. Luckily ARANZ has continued to base its product development in Christchurch.

This case study also points to the broader opportunities to digitise health information in New Zealand, as discussed in section 3.3. below. With appropriate "pipe infrastructure" it would be much easier for telehealth systems like those of ARANZ Medical to plug and play into the health system, feeding information to clinicians and patients alike.

Source: Interview with ARANZ Medical.

The Government intends to reduce the number of DHBs to 8-12. This may make it easier for HealthTech firms to engage with them but, more importantly, DHBs need a mandate, culture and incentive to participate in the health innovation ecosystem. The Commission's recommendations on this issue can be found in Chapter 10 of the Commission's frontier firms report. The cooperation of DHBs will still be required for the HealthTech innovation ecosystem to reach its potential.

3.3 Smart regulation provides an advantage

Given New Zealand's distance from international markets, a vibrant and growing HealthTech sector may come as a surprise to many New Zealanders. One of New Zealand's attractions for HealthTech companies seems to be that its regulatory regime allows them to test new ideas in a relatively low-cost way, with the exception of the DHB issue raised above.

Regulation is a massive issue for HealthTech

Internationally, the health industry is heavily regulated. The process of bringing a new product to market is extremely rigorous and time-consuming. In some cases it can take many years to bring technologies through the R&D cycle and get over regulatory hurdles (NZHIT et al., 2016). This level of regulation is understandable given the need to ensure the safety of patients. New Zealand HealthTech firms that export face complex international regulatory requirements, which some struggle to fully understand and navigate.

The long development timeframes in HealthTech mean firms require more capital than other firms, as well as the skills to plan and manage over long timeframes. Industry stakeholders pointed out that Health IT companies generally face lower regulatory barriers than other HealthTech firms, although they do have to navigate complex privacy and security issues.

New Zealand's relatively simple regulation provides a 'nursery'

Industry stakeholders consider that New Zealand's regulatory environment is relatively simple and more conducive to product development and clinical testing than some other jurisdictions. This relative ease of developing, prototyping and testing technologies helps support an efficient innovation system. One interviewee also noted that firms in New Zealand can talk to regulators in a way that is collaborative, and this is beneficial to regulations that are flexible and fit-for-purpose.

A Goldilocks zone exists when it comes to the regulation of HealthTech. Regulations need to be simple enough to reduce the burden on firms. At the same time, overseas countries need enough assurance about the quality of regulation to accept New Zealand products once they have been proven here.

The similarity of New Zealand's healthcare system with those of other developed countries, particularly Commonwealth countries, makes it easier for New Zealand companies to expand into those markets with products created and proven domestically.

New Zealand needs to maintain its edge

Some stakeholders are concerned that the new regulations for medical devices currently under development (the Therapeutic Products Bill and PHARMAC taking over purchasing medical devices for hospitals) may stifle innovation. New drugs already go through a stringent regulatory process and the Therapeutic Products Bill is intended to establish a process to ensure the safety of patients using other products that health practitioners prescribe. PHARMAC has been very successful at controlling costs from their management of the country's drug budget. It has been tasked with doing a similar job for medical devices used in hospitals.

Some firms and industry groups are concerned that the Therapeutic Products Bill will require them to run every change in a product (for a example, Software updates) past regulators (Ministry of Health, 2019). They are also concerned that PHARMAC may be unduly focused on cost and are not open to investing in innovative technology that provides value to patients. "Focussing on price at one point in a patient's care ignores the potential of ensuring value across the entire care continuum. New Zealand's procurement model needs to move from cost-based to value-based" (Medical Technology Association of New Zealand, 2021, p. 4). These issues will require careful consideration during implementation.

The Therapeutic Products Bill has been stalled with Covid-19. The need for balance in regulation is understood by the Ministry of Health. If the Bill is well managed there is the potential to improve the situation for medical device manufacturers since their products will be recognised by a New Zealand regulator when they start exporting.

PHARMAC has been moving cautiously to take over the purchasing of medical devices. It is negotiating standardised contracts for medical devices and plans to complete the process in the next two to three years. When complete, new devices will need to be on PHARMAC's list before DHBs are able to purchase them. This should simplify the sales process for medical device companies. PHARMAC also intends to encourage DHBs to direct savings from its centralised purchasing into cost-effective and

innovative new devices. These developments are promising, although as always the devil is in the detail of implementation.

Crucially, the process for developing and trialling new medical devices will not change. Medical device companies currently seek to work with DHBs to develop and trial new products. To have their devices on PHARMAC's list, companies will need to demonstrate cost-effectiveness. This puts even greater pressure on the development and trial process working well in DHBs, yet (as we note above) it is already a problem, particularly for disruptive innovations.

As mentioned, this issue needs resolving within the current health system reforms. DHBs need a mandate and incentive to engage in the HealthTech innovation system. Either PHARMAC or the new regulator of Therapeutic Devices could play a helpful role in coordinating trials and managing links between innovative firms and DHBs. The approach taken by the Canterbury DHB Health Innovation Hub could also be built upon (see section 3.2).

Health IT has plenty of growth potential

Based on this case study, the Commission believes that Digital Health & IT has plenty of potential for growth and adding value. NZHIT notes that the high levels of expertise and connectedness in New Zealand's health system creates opportunities to identify and develop solutions to health problems. The use of digital solutions is increasingly recognised as a key enabler of healthcare service delivery and is moving rapidly to be an essential component of healthcare services as it has in other industries (NZHIT, 2019). As noted above, healthcare costs continue to rise around the developed world and pressure to do things differently is increasing. Health IT has the potential to help improve health outcomes while saving valuable clinician time, as seen by the example of ARANZ Medical above.

The Commission spoke to several stakeholders who emphasised the advantages that Health IT (including the use of cloud technology) could bring to a small, remote and spread-out country like New Zealand. One sector expert tempered this enthusiasm, noting that countries like to have their health data on servers in their own country or at least located in friendly and reliable countries. This, in turn, provides an opportunity for server providers based in this country to service the New Zealand health system.

Industry stakeholders report that New Zealand has many potential advantages in the health data space. They include high-quality health data collected over a long time (including a system of unique National Health Index (NHI) Numbers), well-established ethics committees and processes, and a supportive Privacy Commissioner. These elements taken together make New Zealand a good environment for collaboration in the use of health data.

Another exclusive opportunity is integrating a Māori worldview into health products, as illustrated by Auckland social enterprise WhānauTahi. According to the TIN report (2020a), Whānau Tahi is "the world's first healthcare management system founded on a culture-centric model." Its Software product translates Māori principles of whānau-centric healthcare into an online platform that empowers patients, families and healthcare providers. It is working successfully with local Whānau Ora providers and internationally with indigenous communities in North America with similar perspectives. Whānau Tahi and Emergency Q (Winner of the NZ Hi-Tech Awards 2020) demonstrate the scope for continued growth of kaupapa Māori HealthTech firms.

Realising the full potential of these advantages requires a good health information infrastructure. The Ministry of Health is working on a "national health information platform". This will allow the many different health IT systems to talk to each other and share data via architecture and standards. It may also allow new and innovative uses of data that improve people's health and/or reduce health system costs. Important ingredients for success are high levels of security and trust, and good investment, innovation and commercial frameworks.

The platform is essentially a "pipe infrastructure" to make sure information can flow and go where it needs to. Like ultra-fast broadband it requires a large upfront investment, which will then allow many and varied benefits to emerge. The full scope of those benefits is difficult to predict and value now,

which makes it difficult to establish the business case in order to secure public investment. The Health and Disability System Review (2020) detailed the need for this investment, but the business case has not yet been approved. Meanwhile, other countries are moving on this opportunity, as shown in Box 4 below.

Box 4 **Health Data Right – what are other small advanced economies doing?**

There are a lot of similarities between the use of health data and the consumer data right in the Software case study. The privacy issues and potential benefits to consumers are very similar. The difference is that in that case the banks currently have the data and in the case of health the Government usually has it. As a result, the cost of putting in place the requisite infrastructure for health data sharing falls to the Government.

New Zealand is well-placed given the quality of its health data, but one global digital index recently rated the nation's progress as average (Mechael & Edeman, 2019). Meanwhile other SAEs are moving rapidly to seize the opportunities in this space.

As with most aspects of digital and open government, Estonia is a leading example. The Bertelsmann Foundation ranked Estonia #1 for digital health in 2019. As a result of the country's e-Estonia strategy, around 99% of prescriptions are digital and citizens can access their electronic health records using their digital identification (*E-Estonia*, 2021).

Finland uses the fact that 100% of its population have an electronic health record to advertise the country to international investors as a place to trial innovative technology. Health data can be anonymously matched with other government data to allow for rich evaluation of impact. Data can also be matched with biological samples and phenotype information stored in Finnish bio-banks (Business Finland, 2020).

The Netherlands is much more focused on the health benefits of Health IT for their own population rather than the business opportunities it might present. Their goal is for 75% of chronically ill patients to be able to access their records, monitor aspects of their own health and share the information with their care provider. By using telehealth to spot problems early the health system can intervene to prevent serious complications emerging (Government of The Netherlands, 2015).

4 Horticulture

4.1 A growing industry

Horticulture covers a wide range of produce, including kiwifruit, grapes, apples and pears, berries, vegetables and nuts. The case study focused on kiwifruit and wine, which are the two largest categories by value of production and exports. It examined the growing, processing/value-adding and wholesale distribution of horticulture produce. This includes the picking, packing and storage of fresh produce, as well as viticulture and winemaking.

Horticulture is a large and growing export industry. In 2019, New Zealand's horticulture exports were worth about $5.6 billion, accounting for around 14% of total merchandise exports (up from 11% in 2015). The value of horticulture exports has grown on average by over 13% a year since 2015.[10]

Around 40% of horticulture exports in 2019 were attributable to kiwifruit ($2.3 billion). New Zealand kiwifruit was sold to over 50 countries, with the main markets being China and Japan.

The New Zealand wine industry has seen significant growth over the last 40 years – emerging from virtually nothing to become a $1.8 billion export industry by 2019. It is now New Zealand's largest beverage export. Major markets for New Zealand wine are the United States, the United Kingdom and Australia. The wine industry also generates services exports through international wine tourism. Larger wineries export a greater proportion of their product than smaller firms – the largest firms sell 66% of their wine internationally compared to 31% for smaller firms (Deloitte & ANZ, 2019).

The Māori share of the horticulture industry is growing strongly from a small base. BERL (2020) found that Māori entities accounted for 5% of land in horticulture (excluding viticulture) in 2019, up 300% since 2006.[11] Kiwifruit is the most significant crop, accounting for 9.1% of Māori horticulture land area. Future growth is expected, particularly in kiwifruit, avocados and berries. Several Māori entities have signalled plans to develop pastoral land into horticulture (BERL, 2020).

Success has come from quality and price premiums

Both kiwifruit and wine have scale and are global leaders on quality. New Zealand is the second largest producer of kiwifruit in the world after China. New Zealand kiwifruit accounts for 33% of global production by volume and 67% by value, reflecting its place as a niche, premium product. New Zealand kiwifruit is renowned for its consistent, premium quality, and the pleasant taste and texture of the Gold varieties are highly popular with consumers.

New Zealand wines also compete strongly on quality and earn price premiums in global markets, even against long-established 'Old World' producers (such as France). Marlborough sauvignon blanc, renowned for its distinctive aroma profiles, dominates production and exports.[12] New Zealand wines are either the highest or second-highest priced wine category in the United States, the United Kingdom, Canada and China (New Zealand Winegrowers, 2019).

High and growing yields and returns

The value per hectare from horticulture, notably kiwifruit, eclipses other agricultural industries. The wine industry has relatively lower returns per hectare compared to other horticultural industries, yet at $19 400 per hectare (in 2017) it significantly exceeds those from other agricultural land uses.

New Zealand kiwifruit and apple yields (production volumes per hectare) are high by international standards, and have been increasing over time, particularly in kiwifruit. Kiwifruit orchard gate returns

[10] Year ended December 2019. Figure includes fresh and processed fruit, vegetables and nuts, as well as winemaking. It includes juices, but excludes categories (such as grains, fats and oils, cut flowers and vegetable seeds).

[11] Including Māori authorities and businesses where the owners self-identify Māori ownership and management in the BOS.

[12] In 2019, sauvignon blanc accounted for 62% of producing vineyard area and Marlborough for 69% (up from 51% and 58%, respectively, in 2010). Sauvignon blanc comprised 73% of the 2019 vintage by volume (up from 66% in 2010) and 86% of export volumes (up from 82%) (New Zealand Winegrowers, 2019).

have also been increasing, having grown from an average of $35 655 per hectare in 2009 to $107 142 per hectare in 2020. Returns vary by cultivar, with innovative new cultivars attracting significantly higher returns. For example, the SunGold cultivar generates average returns of $161 660 per hectare compared to $67 295 per hectare for the original Green variety (Zespri Group Ltd, 2020a).

Frontier firms are more capital-intensive and more likely to export

Labour productivity has been improving in the Horticulture industry, including in its frontier firms. However, the productivity of its laggard firms has remained at around 23% of its frontier firms over 2001 to 2018 ($61 910 compared to $272 630 of value-added per FTE). This stable productivity distribution mirrors that of New Zealand as a whole.

Most capital stock in the industry (64%) is invested in firms with the highest labour productivity. However, a significant proportion of employment (68%) is in the middle and lowest productivity firms, and this distribution has not changed materially since 2001. It shows that the lower productivity firms are more labour-intensive, and suggests their productivity could be improved by greater application of capital. It also indicates that the reallocation of workers from low to high productivity firms is not happening as much as desirable.

Frontier Horticulture firms are more likely to export than laggard firms and are responsible for the majority (74%) of the industry's exports. They also have higher average annual wages – at $67 960 compared to $45 830 for laggard firms.

A trend of rapid consolidation

Across the fresh produce sector, there has been a trend of rapid consolidation into fewer, larger growing and handling operations that can achieve the benefits of scale. For example, there has been significant consolidation in the packhouse sector since the 1990s for both kiwifruit and apples (Coriolis Research, 2013). The apple industry is also consolidating into large-scale integrated grower / packer / shipping operations (Coriolis Research, 2020).

In wine, the number of growers has decreased from 1 128 in 2010 to 692 in 2019, while the area in production increased from 33 200 to around 38 680 over the same period. The number of wineries increased from 672 to 716 (New Zealand Winegrowers, 2019).

Box 5 **The productivity benefits of scale and automation**

Bostock New Zealand is a large horticulture firm based in Hawke's Bay. As well as being New Zealand's largest organic apple grower, it also produces squash, onions, wine, grain and organic chicken.

The firm illustrates many of the features of frontier Horticulture firms. It has shown strong growth, with total revenue increasing from $80 million in 2010 to $204 million in 2020 (annual growth of 10% over 10 years). Ninety per cent of its revenue comes from exports, well above the average export intensity of 38% for the horticulture industry as a whole.

Revenue growth has been supported by increases in both scale and productivity. For example, the area planted in apples has increased significantly, from 366 hectares in 2011 to 563 hectares in 2021. Greater scale can generate productivity benefits by spreading fixed costs over a greater volume of output.

The firm has also invested heavily in labour-saving automation (such as a machine to pack squash in bins and an electronic onion-packing tower). A $500 000 investment in the automatic squash bin fillers increased the speed of packing and reduced the number of employees needed (see photo). The business also made other efficiency improvements, including by improving produce quality and reducing the number of varieties grown. These initiatives combined raised labour productivity (measured by tonnes per hour worked) by 93% over two years.

The scope for automation is currently greater in the packhouses than in on-orchard activities such as picking. Technologies for orchard activities are still some years away. In the meantime, apple growers like Bostock New Zealand are investing in equipment such as hydraulic platforms that reduce the physical effort required to pick. For example, the platforms remove the need for pickers to carry heavy baskets up ladders, which brings the task within the capacity of more workers (including women) and may make the jobs more attractive to local workers.

John Bostock is Bostock New Zealand's owner. He says that the certainty of a reliable seasonal labour force, comprised mostly of RSE workers, has enabled increases in output, investment in mechanisation, and an increase in permanent positions. Total employment in the firm has grown at a similar rate to revenue, yet permanent roles have grown faster. As a proportion of the total employee headcount, permanent jobs have increased from 29% in 2014 to 34% in 2019 (this proportion is much higher during non-peak months, as most casual labour is employed during the harvest and packing season). John Bostock sees the creation of permanent, fulltime positions as critical to the future of the horticulture industry.

Source: Pers. comm. John Bostock and Neil Chittock, Bostock New Zealand, 21 December 2020 and 29 January 2021. Photo provided by Bostock New Zealand.

4.2 Strong growth prospects, but capacity constraints

Global demand is strong

Global demand is growing, and New Zealand has a strong track record of premium products. New Zealand kiwifruit and wine are both well-recognised brands that are trusted by consumers. Significant potential exists for continued export growth, and Zespri aims to increase its global sales revenue from $3.14 billion in 2019–20 to $4.5 billion by 2025 (a compound annual growth rate of 7%) (Zespri Group Ltd, 2020b).

The two industries are very much consumer-facing, with their innovation systems highly aligned to consumer tastes. It will be important for both industries to remain at the leading edge of rapidly changing consumer trends.

Growing consumer demand for sustainable, ethical products

Consumer demand for sustainable, ethical products is growing. Work by Lincoln University has found that consumers are prepared to pay price premiums for food products with socially responsible and environmentally sustainable credence attributes. For example, consumers in developed countries are

prepared to pay a premium of 16%–30% to raise the socially responsible standard of fruit and vegetables from "minimum" to "improved" (Miller et al., 2017; Tait et al., 2016).

In terms of environmental and social credentials, kiwifruit is well-placed. Zespri, which has an almost complete exporting monopoly, requires growers to comply with its Zespri System of orchard management. This system includes ZespriGAP, an audited process that is based on the internationally-recognised GlobalGAP standard for environmental and ethical best practices (Zespri Group Ltd, 2021). Wine too has sustainable wine-growing programmes – 98% of production area is certified under the Sustainable Winegrowing New Zealand programme, which like the kiwifruit programme has audit processes (New Zealand Winegrowers, 2020b).

New Zealand's distance from markets, particularly European markets, poses a challenge to firms' environmental credentials. Innovations in packaging can help reduce the weight of exports. For example, Marlborough sauvignon blanc is increasingly shipped in huge, container-sized bladders, and then bottled overseas closer to market (Lewis & Le Heron, 2018). Other solutions include greater investment in growing offshore (as Zespri has been doing and which also supports counter-seasonal supply and does not contribute to the domestic peak capacity problem). Better distribution logistics are another option, and both Zespri and some wineries have vertical control of their distribution network.

Box 6 **Opportunities for Māori firms**

The growing consumer demand for sustainable products presents opportunities for Māori firms and collectives. Several stakeholders commented that firms based on te ao Māori resonate well with consumers looking for products with strong environmental credentials and features (such as provenance and authenticity).

There are many successful Māori firms in the Horticulture industry that are based on Māori values and approaches. Here are two examples.

Kono is a business arm of Wakatū (a Māori Land Trust). Kono is a vertically integrated, family-owned food and beverage producer and exporter of award-winning wines, as well as cider, seafood, fruit and natural fruit bars. Kono has a strong intergenerational focus and works to a 500-year plan (Te Pae Tawhiti). Their business approach is underpinned by the principles of kaitiakitanga, which are reflected in its adherence to certified sustainable and ethical production practices.

Miro is a partnership between 28 Māori authorities and investors that produces blueberries for export. It has a long-term goal of transforming 500–1 000 hectares of Māori land into productive horticulture. The business is underpinned by Māori values and sustainability. For example, its Eureka variety of berries are planted in polytunnels and fed by a "fertigation" system that creates a low environmental footprint.

Chapter 4 in the Commission's inquiry report on frontier firms considers the characteristics of Māori firms, and the growth opportunities these present, in more detail.

Source: Kono, 2020; Miro, 2020; Skellern, 2020.

However, the industry is facing capacity constraints

While kiwifruit and wine have strong growth prospects, both are facing domestic capacity constraints, particularly in relation to labour, land and water (ANZ, 2019; New Zealand Winegrowers, 2019). ANZ reports that substantial land-use change will be required to accommodate the expected growth in SunGold kiwifruit in the Western Bay of Plenty. However, land is available in the Eastern Bay of Plenty and greenfield development is occurring in other regions. Kiwifruit also faces constraints in post-harvest capacity, which will be exacerbated as the volume of fruit continues to grow (ANZ, 2019).

A strategic review of the wine industry by PwC found that commercially suitable land in Marlborough is nearing capacity. The review argued that local wineries will increasingly need to focus on adding value and raising productivity (New Zealand Winegrowers, 2019). This regional capacity constraint could pose a more general risk to the New Zealand industry, given its reliance on Marlborough production. The strong growth in the industry has been driven by consumer demand for the highly distinctive attributes of Marlborough sauvignon blanc:

> It is Marlborough sauvignon blanc that distributors and retailers look for in the wine portfolios of New Zealand wine exporters; and it is Marlborough sauvignon blanc that gives these exporters the volume presence in markets necessary to sell other wines. (Lewis & Le Heron, 2018, p. 122)

Wine also risks falling into a commodity trap

Average yields in the wine industry have grown from 7.8 tonnes per hectare in 2000 to 10.7 tonnes in 2019 and the volume of exports has increased significantly. Yet while grape prices have been increasing, the price per litre of wine exports has declined from a peak in 2002 and been flat over the last decade. The combination of static prices and rising costs is lowering profits per hectare. Average before-tax profits per hectare in Marlborough were $8 700 in 2019, down from $14 800 in 2016 (New Zealand Wine & Ministry for Primary Industries, 2019).

Most Marlborough sauvignon blanc, and some other varieties, are now produced at an industrial scale by large firms who sell in bulk to overseas supermarkets and retail chains (some of whom then pack their own-brand wines). This contrasts with the smaller, more artisanal wineries that produce other wine categories, and have different picking, processing and marketing methods. These smaller wineries tend to focus on specialist retail (such as on-premise and restaurants). This divide has been exacerbated by Covid-19, which has heavily impacted the high-end retailers and restaurants relied on by smaller companies, while benefiting large-scale retail.

Lewis and Le Heron (2018) suggest that the dominance of Marlborough sauvignon blanc, with its shift to industrial-scale production and a fast-moving consumer good business model, risks pulling the industry into a commodity trap. They identify the bulk exporting and high-volume sales of Marlborough sauvignon blanc as a key driver of the drop in average prices for New Zealand wines and a threat to the profitability of smaller, more family-owned wineries, which focus on smaller volumes and higher prices. To the extent that these smaller wineries gain presence and access off the back of sauvignon blanc, this could represent something of a conundrum.

The challenge for the wine industry is how to grow while maintaining prices and without compromising on quality. Increasing productivity through the uptake of new technologies and practices is one way; diversification of wine styles is another. Other New Zealand wines (such as high-end pinot noirs) sell at premium prices and into different markets. Lewis and Le Heron (2018) point to mid-sized firms (such as Pegasus Bay and Palliser Estate), which have scaled up production while retaining premium status, and Villa Maria, which has differentiated its wine types to suit a range of market segments.

Low-alcohol wines are another route to diversification. New Zealand appears well-placed to be a global leader in this area with a major research programme under way. "Lighter wines" is the industry's largest R&D endeavour to date. A consortium of 18 companies has secured $17 million over seven years in government co-funding from the PGP.[13] The programme focuses on the natural production of wines that are lighter in alcohol (Ministry for Primary Industries, 2019).

4.3 A busy innovation ecosystem

An extensive array of institutions and funding

Key institutions in the Horticulture innovation ecosystem include the following:

[13] As noted earlier, the PGP has been closed to new programmes since it was replaced by the SFF Fund. Lighter wines is one of a number of PGP programmes still under way.

- The Horticulture industry is served by a major CRI, Plant & Food Research. It conducts R&D related to fruit, vegetables, crops and food products. Plant & Food receives $43 million a year from the government's Strategic Science Investment Fund.
- Zespri is a growers' cooperative formed in 1997. It operates as a single-desk marketer and uses sophisticated licensing to protect its IP. Zespri has a strong track record of innovation, including new-to-the-world products (such as the Zespri® SunGold variety). Zespri has three main income streams: kiwifruit sales; Plant Variety Right (PVR) licensing fees charged to growers (discussed below); and royalties on its new cultivars. Total investment in kiwifruit innovation was $44 million in 2018–19, with $31 million of this coming from Zespri (Zespri Group Ltd, 2019).
- The Bragato Research Institute (BRI) was established in 2017 as a Regional Research Institute for the wine industry (both grape growers and winemakers), with five years of establishment funding from the Ministry of Business, Innovation and Employment (MBIE) and the Marlborough District Council. Its research is currently funded through a mix of industry levy, participating companies, the MBIE Partnership Fund, the Endeavour Fund, and the PGP and the Sustainable Farming Fund (now combined into SFF Futures) (New Zealand Winegrowers, 2019, 2020a).
- PlantTech is an industry-led research institute focused on developing digital automation/AI solutions for horticulture. It received establishment funding of $8.425 million from MBIE's Regional Research Institute Fund.
- The Riddet Institute is a CoRE. Its research programme is focused on the effect of food structure on digestion and health for the food industry.
- The Food Innovation Network (NZFIN) comprises four open-access food and beverage pilot and scale-up facilities. In addition, FoodHQ in Palmerston North is a food research and innovation hub. The NZFIN facilities are currently funded through a mix of central government funding and user charges, the proportions of which vary by facility.

Major research initiatives that the government funds include:

- SFF Futures – this is a new co-investment fund that resulted from a merger of two pre-existing funds, the PGP and the SFF. The fund aims to support the sustainable development of New Zealand's food and primary sectors.
- The High-Value Nutrition Science Challenge – which aims to "develop high-value foods with validated health benefits to drive economic growth." It involves up to $83.8 million of government funding over 10 years (MBIE, 2020b).

Strong industry organisations provide cohesion

Zespri performs many of the roles that large firms play in industry clusters. It helps generate and protect the intangible assets of the industry, acts as an anchor for the myriad of growers and other supporting firms (such as post-harvest operators) and provides sufficient scale for the industry to be at the global frontier. Zespri's performance is monitored by the New Zealand Kiwifruit Growers Inc (NZKGI), an industry advocate body for growers.

The Commission heard from stakeholders that the diffusion of new ideas amongst kiwifruit growers occurs rapidly. This is largely driven by Zespri, with knowledge translation and transfer supported by partner organisations (such as Plant & Food), as well as growers themselves. Zespri's approach to innovation and diffusion, underpinned by a strong customer focus and long investment horizon, provides a model for other industry organisations.

Like kiwifruit, the wine industry has a strong and well-recognised national-level brand that is trusted by consumers. It has a well-regarded industry body that provides cohesion to the industry. New Zealand Winegrowers was established through the merging of the New Zealand Grape Growers Council and the Wine Institute of New Zealand. The organisation has helped build the sense of collective interest in the industry through a "cleverly constructed governance structure and commitment to a binding ethic

of quality… [that] is widely reputed to set the standard for open and effective industry leadership" (Lewis & Le Heron, 2018, p. 119). As noted above, the industry also has a dedicated research institute. The Bragato Research Institute's research focuses on aspects of grape-growing and winemaking that are unique to New Zealand (such as managing biosecurity risks and diseases, vineyard management techniques to reduce costs, and quality wine styles for existing and developing markets). BRI also plays a role in technology transfer.

The Commodity Levies Act is an important piece of enabling legislation that provides for levies to be imposed (under Commodity Levies Orders) and paid to industry organisations to fund industry-good activities (such as research, product development, and marketing and promotion). Commodity levies are in place on a range of produce, including kiwifruit growers and grape growers and wine producers, to help fund the NZKGI and New Zealand Winegrowers. respectively.

Other emergent Horticulture industries (such as avocados and various berries and nuts) do not yet have the strong industry structures needed to drive cohesion and innovation. The process of scaling up emerging Horticulture industries will be complex and challenging. It will require a systems approach that integrates biological production decision making with consumer-facing business decisions. Well-developed industry bodies will be needed to coordinate information flows and engage with key stakeholders (such as government parties). Chapter 7 in the inquiry report discusses other aspects of industry development in the context of focused innovation policy.

Box 7 **Innovation in the apple industry**

Like kiwifruit, the New Zealand apple industry has also turned its fortunes around, shifting from low-value commodity production in the 1990s to today's premium products. The World Apple Review has consistently ranked the New Zealand apple industry as the most competitive in the world.

Similar to the kiwifruit story, the apple industry's success has involved developing and commercialising new varieties. The IP is protected through PVRs and licensing arrangements. The industry is increasingly using selective licensing to manage global production, as well as control quality, branding and marketing. This helps maintain brand values and price premiums. Environmentally sustainable growing practices and post-harvest technologies have also contributed to this success (Legun, 2018). The industry body, New Zealand Apples & Pears, ensures consistency of growing practices and is responsible for technology transfer to New Zealand growers.

Licensing arrangements were first implemented when the industry had a single-desk marketer (the Apple and Pear Marketing Board, subsequently ENZA). Following the deregulation of the industry in 2001, Turners & Growers (now T&G Global) purchased ENZA, including its IP system. Katharine Legun explains that this corporatisation led to the simultaneous emergence of a highly integrated, global production system and strong national branding, tied with a long-running national breeding programme (Legun, 2018).

As with kiwifruit, the apple industry has had a longstanding relationship with Plant & Food and its predecessor CRIs. Global commercialisataion of new varieties of apples and pears bred by Plant & Food occurs through Prevar, a joint venture company whose shareholders are New Zealand Apples & Pears (55%), Plant & Food and Apples & Pears Australia.

Source: Legun, 2018, New Zealand Apples & Pears, 2018, 2021.

But government supports could be improved

The innovation system was the area for improvement most raised by industry stakeholders. The system (across the food and beverage sector, but also more generally) was described as siloed, fragmented, unhelpfully competitive, hard to navigate and disconnected from industry needs. In Chapter 6 of the inquiry report, the Commission makes recommendations for improving the accessibility and coherence of the Government's innovation supports and interventions, across the economy as a whole (not just in horticulture or food). Some specific ways the Government could better support innovation in Horticulture are outlined below.

Constraints in the post-entry quarantine system are choking innovation

Both kiwifruit and viticulture are vulnerable to incursions of harmful pests and diseases. As such, their fortunes rely on their research programmes, which must remain alert to risks. Stakeholders from the research community expressed concern about how difficult it is to import new plant material. They argued that this difficulty is constraining research, including research on potential biosecurity threats.

Bringing in new genetic material requires a current import health standard (IHS) to be in place for the plant species, and for the material to be held in an MPI-approved post-entry quarantine (PEQ) facility for inspection and/or testing prior to biosecurity clearance. Participants described significant delays and backlogs in the PEQ process due to limited physical capacity. There is also a longstanding backlog in MPI's development of risk analyses and associated IHSs.

Chapter 10 of the inquiry report contains the Commission's advice on improving the capacity and efficiency of PEQ processes.

The current regulation of GM does not reflect technological advances

Stakeholders expressed concern that restricted access to GM tools is inhibiting the industry's ability to prepare for biosecurity threats. They said the current regulatory regime is also acting as a barrier to innovation and the ability to seize significant opportunities, as well as protect existing markets.

HSNO defines genetically modified organisms (GMOs) as those that contain or are derived from genetic material that has been modified *in vitro* (in a test tube or petri dish). Regulation sets out a list of techniques that are captured by the GM definition, but which are exempt from regulation on the basis that they have been deemed safe and were in use before 29 July 1998 (the not-GM regulations). The regime therefore defines GMOs by the process through which they have been developed, rather than the attributes of the resulting products.

However, technologies have moved on significantly over the last 20 years. Modern gene-editing techniques enable changes to be made *in vivo* (directly inside an organism), a technique that was not envisaged at the time the current regulations were made. Modern gene-editing techniques can also produce changes that are indistinguishable from naturally occurring organisms, and indistinguishable from changes made by techniques that are exempt from regulation (Ministry for the Environment, 2018, p. 1). Chapter 10 of the inquiry report sets out the Commission's recommendations for ensuring the regulation of GM is fit for purpose and enables domestic innovation.

4.4 Potential for greater use of technology and automation

The industry is heavily reliant on seasonal migrant labour

Horticulture New Zealand considers the industry's single biggest constraint is a reliable supply of seasonal and permanent workers (Horticulture New Zealand, 2018). The industry is highly seasonal, with the peak periods for picking and packing for some crops lasting just a few weeks each year.

Horticulture growers struggle to find sufficient local labour to meet their seasonal employment needs. This is partly because the work is unattractive to many local workers, due to relatively low wages and piece rates in some roles, the strenuous and short-term/insecure nature of the work, and often the need to temporarily relocate. However, it also reflects other difficulties with the pool of long-term

unemployed. Industry stakeholders told the Commission that despite ongoing efforts to train and employ locals, they encounter problems with drug use and absenteeism.

NZKGI predicts the kiwifruit industry will need an additional 8 000 seasonal workers by 2027 to cope with the planned increase in production (NZKGI, 2018). The wine industry experiences persistent shortages of skilled permanent staff, including machinery operators, mechanics, managers and supervisors (New Zealand Wine & Ministry for Primary Industries, 2019). Pre-existing industry concerns about labour shortages have been exacerbated by the border closures prompted by Covid-19 (Frykberg, 2020).

The dependence on seasonal migrant labour is inhibiting capital investment

Greater use of technology and automation could help ease the Horticulture industry's labour supply constraints by reducing its reliance on seasonal workers. It could also improve the efficiency of growing and other operations and lift industry productivity.

However, the seasonal peak combined with the relatively low cost of labour (compared to capital) act as disincentives to the development and uptake of automation. For example, the average pay rate for kiwifruit seasonal workers in 2018–19 ranged from $18.01 per hour for unskilled packhouse workers to $22.89 per hour for picking Gold kiwifruit (the minimum wage was $17.70) (NZKGI, 2018). These factors make it challenging to achieve an acceptable rate of return on capital investment in labour-saving and productivity-enhancing technology.

Horticulture firms told the Commission that the uptake of automation overseas is being driven by rising labour costs and employment standards, as well as more favourable depreciation rates on machinery and equipment. In places (such as the United Kingdom and the United States), labour shortages due to Covid-19-related border closures (and in the United Kingdom, also Brexit) are accelerating interest and investment in robotics for harvesting crops (J. Evans, 2020; Hodge, 2020; Terazono, 2020). Higher wages could also spur investment in growing and harvesting practices and in technologies that reduce the strenuousness of the work (and therefore help make it more attractive for local workers). As Nunns et al. (2020) point out, automation creates new types of jobs that are more skilled.

In kiwifruit, the main uptake of automation to date has been in packhouses, as it is harder to achieve the results and speed needed for on-orchard automation of activities like pruning and picking. Tauranga-based firm Robotics Plus is a high-tech company focused on solving the challenges facing the Horticulture industry, particularly for apples and kiwifruit. It has won multiple awards, including the 2019 Hi-tech Awards Most Innovative Māori Company of the Year and the 2019 ANZLF Trans-Tasman Innovation and Growth Award. The company has been working for some years on a robotic kiwifruit picker, but commercial production has yet to begin.

While most packhouse technology comes from overseas, it is often adapted from other types of horticulture as there are few other kiwifruit-producing countries with incentives to invest in developing bespoke technology. However, the Commission heard in engagement meetings that the approach to such problem-solving is piecemeal, given the competitive nature of the post-harvest sector. As a grower-owned cooperative, Zespri's work focuses predominantly on on-orchard activities.

Growth potential in agritech

Potential exists for New Zealand to develop and commercialise technologies that support Horticulture industries and raise productivity. While the market for bespoke technologies for kiwifruit may be limited (it comprises a very small share of the total global fruit supply), other industries (such as apples and viticulture) offer potential. Technologies that can be flexed or adapted to help produce different products (such as other fruits) are another prospect.

Box 8 **Labour shortages spurred innovation in the wine industry**

Automation is already widespread in the wine industry, with the larger firms operating at industrial scale. For example, most Marlborough sauvignon blanc is harvested by machine, then processed in bulk in stainless steel tanks by contract processors. However, pruning has proved a difficult aspect of the production process to automate.

Pruning grape vines (cane pruning) is labour-intensive. The process involves selecting which vines to retain (typically four out of 20 vines attached to the trellis wires), cutting the unwanted vines and then stripping them out from the trellising. The task of selecting and cutting the vines is skilled, while removing the unwanted vines is strenuous physical work. Removing the vines is complicated by the fact that they are entangled in the trellis wires.

KLIMA is a company established in 2008 by two New Zealand viticulturists. The company has developed and commercialised a mechanised vineyard-pruning system. The system involves self-releasing clips that free the vines from their trellis posts and wires and a machine that cuts, strips and mulches the unwanted vines.

The "burning platform" for the innovation was a severe shortage of seasonal labour during the 2006 pruning season. This prompted viticulturists Marcus Wickham and Nigel Gerge to rapidly design, prototype and trial mechanised solutions.

The pair engaged IP specialists, EverEdge IP, to help them secure patents. EverEdge challenged them to think beyond the New Zealand market and helped them commercialise the products overseas. KLIMA entered a strategic partnership and licensing arrangement with the German vineyard machinery firm ERO Weinbau to manufacture and distribute the machines across Europe.

The KLIMA system prunes a row of vines in two minutes compared to two hours for a person. The company estimates that their system generates labour-cost savings of 30%–50%, or around $1 000–$1 500 per hectare. Wickham reports that demand for KLIMA products in New Zealand slowed for several years following the introduction of the RSE scheme, which relieved labour constraints and lowered the cost of manual pruning. He says that demand from the United States was initially low due to the availability of low-cost workers, but is now growing due to improvements in local wages and employment conditions.

The pruning machine received a Gold Medal Award at the SITEVI Exhibition in France and the Gold Medal and overall prize for innovation at the SIMEI Exhibition in Italy.

Source: DEMM Engineering & Manufacturing Magazine, 2012, Goode, 2010, KLIMA, 2020, Marcus Wickham, pers. comm., 11 August 2020. Photo provided by KLIMA.

Automation is not straightforward

Automation in Horticulture poses technical challenges. The tasks are many and varied. Some, such as picking, are proving difficult to automate due to the nature of the action required and the complexity and dynamic nature of the field environment (making it hard to achieve the speed and consistency of human pickers). This means that commercialisation could still be many years away for some technologies.

In addition to automation, potential also exists to extend the harvest season through breeding, for example, the new Red kiwifruit matures a little earlier than Gold. From Zespri Global's perspective, another option is overseas plantings, which are occurring. A future possibility, requiring radical innovation, could be the indoor growing of some crops.

Packhouses already extend the packing and storage window, with techniques (such as controlled atmosphere storage) where some fruit is placed straight into storage and sorted later. To the extent that seasons can be extended, the investment case for automation improves.

The Commission's recommendations for transitioning the industry away from its reliance on seasonal migrant labour and accelerating the development and uptake of productivity-enhancing technologies are set out in Chapter 9 of the inquiry report.

5 Software products and services

The Software products and services industry (the Software industry) consists of over 12 000 firms (Stats NZ, 2020b). Software products firms develop or improve software applications (including software as a service (SaaS) and web-based applications) sold in global markets. Software services firms, however, mostly provide IT infrastructure (including database management, system integration and security) to domestic enterprises. Auckland and Wellington host 80% of New Zealand's software firms.[14]

The Software industry includes firms "engaged in providing expertise in the field of information technologies (such as writing, modifying, testing or supporting software) to meet the needs of a particular consumer; or planning and designing computer systems that integrate computer hardware, software and communication technologies" (ABS, 2013).[15]

Software is a subset of the broader Information and Communication Technology (ICT) and digital sectors, which in turn are subsets of the "tech" sector. Some subsectors of the broader tech sector include Software firms, for example, HealthTech (explored in section 3) and FinTech (as explored below). [16]

5.1 A growing weightless industry

The broader ICT and digital sectors have slightly different statistical definitions, but both include Software in their scope. Both ICT and digital have grown strongly in the past decades. In both cases, Software has been the major driver. For example, ICT exports overtook wine to reach $2.1 billion in 2019, a 300% increase over 2010 (Stats NZ, 2020d). Software is a small industry, yet it has been the fastest growing part of the ICT sector. Looking across the digital sector, Stephenson (2019) found that around half of the growth of the digital sector between 2001–16, in both the number of firms and employees, was due to the growth of the Software industry.

The contribution of the Software industry to GDP (that is, its value-added) has tripled during the last 15 years, reaching $5.3 billion (1.7% of GDP) in 2019 (Stats NZ: customised data request, 2020). In the same year, software firms exported over $1.2 billion (Stats NZ, 2020f), and their total revenue reached $10 billion, up from $6 billion in 2013 (Stats NZ, 2020a).

In 2020, the Software industry employed 35 000 employees, up from 11 000 in 2000, with average earnings of $105 000 per year. This earnings figure is roughly double the New Zealand median wage (Stats NZ, 2020b, 2020e). Of the 12 000 software businesses, about 2 500 are employing staff. Only 500 firms have more than 10 employees. Software firms, on average, employ three staff. This reflects the high number of start-ups and small-to-medium enterprises (SMEs) in this industry. Stephenson (2019) suggested that growth in the digital sector "is more highly concentrated in firms that are born small, compared to non-digital (comparator) firms" (p. 23).

More than half of employment growth is coming from the larger businesses (with 100+ employees) (MBIE, 2017). This is a promising sign of a maturing industry, achieving the scale that is helpful to compete in international markets.

ICT firms are closing their productivity gap with their international peers

New Zealand has far fewer employing firms in the broader ICT sector, compared to other SAEs.[17] Yet these New Zealand firms have been very successful in closing the productivity gap with their SAE peers. This has happened across the board, with frontier, median and lagging firms all improving their

[14] The statistics for the Software industry do not include IT departments of firms/organisations if software is not the predominant activity of the business.

[15] The Australian and New Zealand Standard Industrial Classification (ANZSIC) refers to the industry as Computer System Design and Related Services (M7000).

[16] Financial technology: specifically, new technologies and innovations that challenge traditional methods of delivering financial services (such as banking).

[17] New Zealand has 21 000 employing firms in the ICT sector. Belgium, Denmark, Sweden and Finland have, on average, 170 000 employing ICT firms (authors calculations based on CompNet data used in Zheng et al. (2021)).

productivity relative to their SAE peers. Zheng et al. (2021) indicate that ICT is the only sector in their study in which labour productivity is growing faster than in other SAEs. The sector has gone from 56% of SAE labour productivity in 2003–08 to 77% in 2009–16.

As with other sectors, frontier ICT firms in New Zealand are behind, but they are closing the gap faster than in any other sector. In 2003–08, the SAE frontier firms in ICT had productivity that was 92% higher than their counterparts in New Zealand. For the 2009–16 period, that figure dropped to 62%. For the economy as a whole the productivity gap increased from 70% to 120% (Zheng et al., 2021).

Potential for strong future growth

The Software industry has been growing significantly across the world. The Covid-19 pandemic has increased the pace of digital transformation and the growth of the industry[18]. The case study found that Software, as a weightless industry, has the potential to grow strongly in New Zealand. The following sections explain some of the factors that could support or hinder the growth of the industry in the future:

Intangible assets create unique challenges and opportunities

A key feature of the Software industry (closely related to its weightless character) is that firms rely mostly on their intangible assets, including intellectual property (IP) and human capability[19]. The importance of the rise in intangible capital in advanced economies and the role it plays in driving productivity growth is uncontested. An economy with a lot of intangible capital differs significantly from traditional economies as intangible assets are more likely to be Scalable, have Sunk costs, create Spillovers and have Synergies with other inputs (the 4 'S's) (Haskel & Westlake, 2018).

These properties have deep implications for business practices and economic policies in areas such as innovation and R&D, finance and investment, statistical measurement, skills, management and leadership, infrastructure, regulation and inequality.

For instance, while software start-ups can be funded by both equity and debt, the latter is problematic because it mostly requires tangible assets for security. Therefore, a case may exist for government to support start-ups and other SMEs to raise more equity to invest in intangibles. One way it could do so would be to encourage big investors (especially sovereign wealth and retirement funds) to invest a small portion of their funds in innovative SMEs.

As argued in Chapter 6 of the Commission's report on frontier firms, the spillovers and synergies that intangible assets generate can justify higher levels of innovation support

Software-products firms have the potential to create significant value

Many of the major software services businesses in New Zealand are international firms (for example, IBM and Fujitsu). In contrast, many of the software-products firms are home-grown. Software-products firms tend to be high-margin and high-growth businesses that have the potential to create significant value. These firms are driving the industry's exports and international footprint (MBIE, 2017). This category includes various SaaS businesses such as Xero, Serko, Gentrack, Vend and Pushpay.

FinTech is the fastest-growing Software subsector (with a five-year annual revenue growth rate of 31%), mostly focused on developing software products. Digital media (including games and entertainment, animation - Box 9), health, artificial intelligence, Extended Reality (XR) (including virtual, augmented and mixed reality (VR/AR/MR)), and online auctions have also experienced notable growth and offer promising opportunities in the future (TIN, 2020b; MBIE, 2017).

[18] "More than 80 per cent of employers intend to accelerate plans to digitise their processes and provide more opportunities for remote work, while 50 per cent plan to accelerate automation of production tasks", according to a survey of global firms conducted by the World Economic Forum in 2020 (The Economist, 2020).

[19] BOS data suggests (new and existing) staff are the main source of innovative ideas, followed by books, internet and conferences, and customers.

Box 9 **"Game On": Going digital takes New Zealand's game industry global**

Games are now serious business. New Zealand's game industry has grown $120 million during the Covid-19 pandemic, topping $324 million in revenue in the year to April 2020. While starting from a small base, growth has averaged 42% a year for the past six years – since well before the start of Covid-19. Most of that revenue (96%) comes from exports. The industry includes 42 companies employing over 740 skilled staff in New Zealand. Like Software more broadly, finding experienced staff is the most often cited barrier to growth in the industry (New Zealand Game Developers Association, 2020).

The rapid growth of the industry is equally due to Kiwi creativity and early adoption of digital business models. Several factors have allowed this hi-tech creative industry to take flight.

First, like many modern software and creative industries products, games software is an intangible asset. Creating the product comes with upfront costs – many hours of input from highly skilled technical and creative people to create the IP. Once the product is created, it is highly scalable and can be sold to unlimited numbers of users at little additional cost. Crucially, for a country in a remote part of the Pacific Ocean there are no shipping costs.

Second, retaining the creative IP in New Zealand hands has enabled more businesses to benefit from licensing deals with new markets and reinvest profits in further product development and jobs.

Third, digital platforms offer a direct route to millions of users around the world. In addition to Apple and Google's app stores, the entertainment industry has international platforms such as the PlayStation store, Xbox store, Fortnite's Epic Games Store and Steam. These platforms innovate with new business models (such as selling optional micro-transactions inside a game or selling additional services or Netflix-style monthly subscriptions).

Of course, these platforms have significant power. They tend to take 30% of the revenue for sales on their site. The marketplace is also crowded, and the platforms can choose which games get featured and are therefore more likely to succeed. This is where Kiwi ingenuity comes in, and this can provide a unique take on an established genre which gets noticed and grows organically.

One example of this potential is Path of Exile, a fantasy role-playing game. Chris Wilson, Jonathan Rogers and Erik Olofsson started development of the game 14 years ago in a West Auckland garage. Key to their market success was creating a community of players, measured in the tens of millions. To do this they made the game free to play and therefore easy to trial. Players can buy cosmetic weapons and armour sets on top of the initial free access to dress up their characters in the game, yet these purchases do not offer any in-game advantage.

This business model is somewhat like the SaaS model used by Xero (Box 10), which has standard and premium offerings. Path of Exile's IP is measured in their audience numbers, with millions of people accessing the game each month. The massive Chinese game company Tencent (owners of games like Fortnite) bought the company for over $100 million in 2018. The company is still based in West Auckland and continues to grow – now with 155 staff.

What is the path to having more games like Path of Exile? Similar to other industries where intangible capital dominates, early-stage funding is a key barrier. Once a company has a prototype for a game it can then seek development funding

from platforms or investors, but industry participants report that funding to build the prototype can be difficult to raise. While game development includes sophisticated technology, its value comes from innovative design. Such design is an example of value creation in a digital, weightless industry but it does not meet the criteria for technology-based R&D tax credits or grants.

Source: Stephen Knightly (pers. comm., 11 March 2021).

Innovation and international connections in software

Every year, over 40% of software firms invest in expansion (MBIE, 2017). Software firms invest significantly in R&D and introducing new products and services (MBIE (2017); BOS). Many firms develop software in-house, in partnership with other firms. Firms also participate in various networking events and work with start-ups that are based in shared offices. This lively collaborative environment allows firms to learn about technology developments, share their skills, and escape the constraints of small scale. The firms also benefit from integrating their software with other, often larger, systems and platforms. For instance, Straker Translations is directly linking its AI-powered platform to IBM's technology platforms to provide translation capabilities through several IBM services (Straker Translations, 2020). These opportunities are important for start-ups that do not have a large client base. Many Kiwi start-ups sell their products via Google Play and Apple's App Store.

The Software industry has strong international connections, partly because it is a weightless industry. Despite having many small firms, the industry has a relatively high rate of internationalisation and New Zealand software businesses are increasingly born global.

- Most software firms (60%) export, even though exports make up a relatively small proportion of their sales (20%).
- Most software firms use goods and services sourced from overseas (BOS, 2015).
- An increasing number of Kiwi firms (over one in 10) are expanding internationally through the acquisition of foreign firms. In 2015, half of the exporting firms reported having a workforce and/or offices overseas. By 2016, 24% of software firms had invested abroad, mostly by establishing a new overseas business or obtaining an ownership interest or shareholding in an offshore firm (MBIE, 2017).
- About 38% of non-exporting software firms are looking to export their products or services. About half are actively exploring exporting opportunities or have initiatives under way, highlighting the global aspirations of software firms.

The BOS data indicate that software firms face lower hurdles to internationalisation than firms in other sectors (see section 6.2), perhaps because they can more easily work and sell remotely. This is important because access to the global markets provides firms with economies of scale and helps them improve their connections with international partners, investors, and experts. Firms can also benefit from involvement in the more competitive global market. The BOS data also illustrate the significant impact of inward and outward investment, and exporting, on the success of innovation activities (discussed in Chapter 5 of the Commission's frontier firms inquiry report).

Software is a weightless industry, which allows New Zealand to overcome the challenge of physical distance from export markets. Software firms "invest more in R&D than any other industry and play a key role in the digitisation and diversification of New Zealand's economy. Through expansion off-shore, they support New Zealand's integration into global value chains and markets" (MBIE, 2017).

These developments are in line with NZPC (2014) and Conway (2018) who recommend the government prioritise and support trade in digital services.

> New Zealand's distance from world markets lends it to specialising in weightless exports, noting that products and services with no weight are costless to transport. With no transport costs,

> New Zealand producers should be able to compete with those in other locations on a "level playing field" – one unaffected by distance. (NZPC, 2014, p. 42)

The Covid-19 pandemic has further highlighted the importance of acting on their recommendations (see section 6.7).

Software is a cross-cutting technology that many other sectors can use to improve their performance. Digital technologies are opening new possibilities by making it easier for firms of all sizes across the economy to engage internationally (for example, using pay-as-you-go cloud services and selling on platforms like Alibaba and Amazon). Recent developments in the Internet of Things (IoT), Artificial Intelligence (AI) and blockchain technologies promise significant and transformational economic benefits. AI Forum (2018) and Vial (2018) describe AI and blockchain in New Zealand, and analyse their potential economic and social impacts and opportunities. MBIE and the AI Forum have recently started developing a National AI Strategy to better harness the benefits of this technology. They are partnering with industry stakeholders to set clear objectives and priorities.

A strong pipeline of growing Māori businesses

The total number of Māori tech firms has doubled in the last three years. The TIN report (2020b) lists The Instillery and Straker Translations in the TIN100, while Whānau Tahi, Sentiment Software and Animation Research Ltd sit on the Next100 list. The report lists a strong pipeline of smaller Māori firms in Software – many in the early stages of their R&D, pre-commercialisation or commercialisation journeys.

5.2 The innovation ecosystem

A privately-led ecosystem, supported by various initiatives

The computer industry in New Zealand has a long history. The first local IT services company, Computer Bureau Limited (CBL), the predecessor of Datacom, ordered its first computer in 1965 (NZ Hi-Tech awards, 2021). In 1967, the major commercial banks pooled their resources to form Databank Limited, to digitise banking services in New Zealand. By the 1980s, Databank had grown to operate the largest computer centre in New Zealand. Progeni, founded in 1968, was the first New Zealand company to export software. It exported education systems to Australia and the United Kingdom (University of Auckland, 2021).

The BOS data show that, over the last two decades, successful start-ups have driven the significant growth of the Software industry. The industry took off after the successful sale of Trade Me to Fairfax in 2006. This exit showed investors the potential of the industry. Also, over time, the founders and managers of Trade Me, and similar successful start-ups, went on to establish various SaaS firms – many of which are now listed on the NZX or ASX, or have been acquired by large, multinational companies. In this way, serial entrepreneurs and other commercially-led founders helped to create an ecosystem in which talent and capital developed and flowed to establish and grow innovative businesses.

Anchor firms play a key role in the success of this industry. For example, the 55% (or $490 million) increase in the revenue of the FinTech subsector in the last two years is largely due to the success of Xero, which grew its revenue by 77% or $311 million (TIN, 2019, 2020b). The FinTech ecosystem is a good example of how an anchor firm provides opportunities for a range of smaller firms for mutual benefit (Box 10).

Box 10 **Xero's FinTech ecosystem**

Xero is a FinTech company providing a cloud-based accounting software platform for SMEs. It was founded in 2006 and listed in 2007. Xero now has more than 3 000 employees across many different office locations. Xero was founded in Wellington and its head office remains there.

Xero has grown rapidly. Revenue growth has averaged 34.5% per year for the past three years. Revenue in the 2020 financial year was $718 million – the 4th highest revenue in TIN. Demand for its product is strong, particularly in the context of Covid-19. Many businesses and accountants have realised the advantage of being able to access their financial information from anywhere, rather than being tied to a server in a fixed location. This trend has lifted the performance of many cloud-based companies.

Almost two-thirds of Xero's revenue comes from Australia and New Zealand, but its presence in the United Kingdom, North America and other countries is growing. While Xero's product is weightless, it still faces hurdles to enter new markets. Its accounting software must be customised to the tax system and other regulations of the host country, and this requires a large one-off investment followed by constant updating.

Xero's role as an anchor firm in the FinTech ecosystem eases the path for other businesses to start-up and grow. Xero has deliberately designed its platform so that other businesses can "plug and play" with the product they have created. This has spawned companies offering complementary products that build on Xero's system, a bit like Apple's App Store. Around 150 000 developers are building software to Xero's Application Programming Interface (API).

Firms spot gaps in Xero's offering and fill those niches. Customers can then pick and choose which add-ons they would like in addition to the main product. The ecosystem also provides a more diverse set of opportunities for people working in the sector. Some Xero employees might miss the start-up culture and leave to start new companies.

Businesses like Spotlight Reporting are a good example of this phenomenon. Its service builds on the information in Xero to provide integrated reporting and forecasting to help businesses gain insights and perform better. Spotlight has been able to follow Xero into international markets relatively easily.

Source: Xero (pers. comm., 16 February 2021).

Anchor firms, industry associations, and angel and venture-capital investors are key contributors to the success of the Software innovation ecosystem. The main centres of innovation (Auckland, Wellington and Christchurch) have established networks of companies, and host initiatives to support learning and connections between firms. Many industry associations and other bodies support this, mostly through networking. While the reach of NZTech is very broad, several bodies (for example, the Artificial Intelligence Forum and TechWomen) target a specific subsector or niche within the wider sector. With this diversity, the industry lacks a single, coherent voice. The BOS data indicate that Software firms have not established many cooperative arrangements with domestic or overseas universities and research institutes.

MBIE, Callaghan Innovation, New Zealand Trade and Enterprise (NZTE) and the National Science Challenge: Science for Technological Innovation all have programmes and initiatives to support the industry. Local councils have funded and set up incubators to support local start-ups. NZ Growth Capital Partners and Icehouse Ventures (both backed by the New Zealand Government) manage several programmes to accelerate the development of early-stage capital markets. Although no dedicated, large-scale research centre (for example, a CRI or CoRE) exists to support the industry, most research institutes have programmes or research groups that work with the industry. The Government, in collaboration with the industry, is developing a Digital Technologies Industry Transformation Plan (Digital Tech ITP) to help lift the performance of the sector and move it to a shared vision.

Government support for innovation is complicated, fragmented and inefficient

Despite all the initiatives, industry stakeholders often claim that it is difficult for business leaders and entrepreneurs to find out what kinds of support are available. This was a common piece of feedback across the case studies. The continual restructuring of government agencies and their support programmes, and changes in government strategy, contribute to the problem. Several stakeholders asked for better collaboration across government agencies to provide more structured and integrated support. Industry stakeholders particularly ask for stronger links between Callaghan Innovation and NZTE, to support firms from ideation to commercialisation and internationalisation.

Some interviewees felt that support agencies can fall into the trap of taking over the direction of young companies, rather than simply giving advice and supporting the efforts of entrepreneurs. Even so, they argued that support is not just about helping with whatever clients ask for. Rather, it can sometimes be about "tough love" and giving honest feedback to entrepreneurs about their areas of weakness. For instance, agencies can help firms apply a commercial lens at an early stage to raise the likelihood that resources (of the firm and government) are allocated to commercially viable projects.

Stakeholders also told the Commission that both grants and R&D Tax Incentive (RDTI) applications are burdensome and that narrow coverage of RDTI is a problem for the industry. NZ Tech's Briefing to Incoming Ministers contended that most of the software R&D previously supported through R&D Growth Grants will not be eligible for the RDTI (NZTech, 2020). Software firms have long had issues in receiving R&D support from government agencies. Partly this is because it is hard to distinguish the original development of a software programme from further testing and improvements. Developers often need to iterate improvements before they can sell and deploy their product, and they must continue to do so after first deployment.

The development of software falls under the same general eligibility requirements as any other business R&D. Yet exclusions specific to software and a cap exist (Taxation (Research and Development Tax Credits) Act 2019 (the Act), Schedule 21, Part A, 11 and Schedule 21B, Part B, 16).[20] The reasons include for greater clarity, to reduce potential fiscal risks, and because of a perception that the spillover benefits associated with internal software development activities are limited (Inland Revenue, 2020). The Inland Revenue guidance notes that:

> Because software development is systematic and iterative and almost always involves testing, businesses may wrongly assume that such software development activities are by their nature, eligible R&D activities.
>
> However, the application of a software development lifecycle, does not mean that eligible R&D is taking place or that the issues being resolved are not being resolved on the basis of existing knowledge, information and expertise.
>
> Unless there is a scientific or technological uncertainty which a competent professional would need to undertake a systematic approach to resolve, there is no basis for a claim for the R&D tax credit. (Inland Revenue, 2020, p. 43)

Inland Revenue is currently reviewing the guidance to improve software developers' access to the RDTI (Inland Revenue, pers. comm., 1 March 2021). Inland Revenue is also investigating whether the definition of R&D should be extended to include tackling system uncertainty which "can arise from or during the integration of technologies, the components of which are generally well known" (NZTech, 2021).

Some stakeholders argue that Growth Grants work better for them, given their earlier payment and the clearer eligibility of experimental development (Edwards, 2020; Roger Ford, pers. comm., 18 February 2021). Stakeholders also suggested that the minimum threshold of R&D expenditure for firms to apply for tax credits ($50 000) is high for software start-ups. The Act allows firms to claim small R&D expenditures if the R&D is undertaken by an "approved research provider". MBIE is considering the

[20] Some of the Schedule 21 exclusions of software-related activities from core R&D activities can still be eligible as a supporting R&D activity.

appointment of some "approved software providers" and an extension of Project Grants, which would fund 40% of the eligible expenditure, to help software start-ups (MBIE, pers. comm., 22 January 2021).

Chapter 6 of the Commission's report on frontier firms makes findings and recommendations about the RDTI and R&D grants.

5.3 Cost, capital and skills are the key barriers to innovation

Access to early-stage investment can be difficult

Most software firms that responded to the BOS reported the cost of developing and introducing new products as a key barrier to innovation. Industry stakeholders told the Commission that venture capital and early-stage investors play a key role in the success of the industry. This is because software firms typically may need to invest substantial sums for long periods before becoming cashflow positive. They also typically lack tangible assets, which banks require as collateral. The investors can also provide start-ups and growing companies with advice, connections and customers, and help them attract follow-on investment, all of which are crucial to their success. Access to finance is particularly important for online platforms that need many users before they become profitable. It can take many years to get to the necessary scale to achieve this.

Early-stage investment has grown markedly over the last two decades, but there is still room for improvements in access to larger amounts of venture capital (beyond Series A) and to public investment via New Zealand's stock exchange (the NZX). The issue of access to finance is highly debated across the industry. Many of the stakeholders who engaged with the Commission suggested that the issue is not the amount of capital available to firms. The issue is rather the lack of specialised advisors and sophisticated investors, combined with a lack of willingness or ability of the larger funds (in which the general public invests) to get some exposure to early-stage companies.

Lack of skilled personnel is a key barrier to innovation and growth

Lack of appropriate personnel, management resources and marketing expertise are also substantial barriers to innovation in this industry, according to both the BOS data and interviews. This is a critical constraint as managers, professionals and technicians comprise 88% of the workforce in the Software industry. In 2016, four-fifths of firms reported vacancies (MBIE, 2017). Firms continue to report high vacancies. For instance, in November 2020, over 2 000 senior IT positions were advertised on LinkedIn (NZTech & New Zealand Digital Skills Forum, 2021). Over two-thirds of the software firms reported that vacancies were hard to fill (Stats NZ, 2020c).

While the skill shortage is evident at the very high end (for example, product managers and international marketing experts), both stakeholders and the data suggest a skills mismatch at the entry level (for example, university graduates) (NZTech & New Zealand Digital Skills Forum, 2021). Graduates in IT fields increased from 3 000 to over 5 000 from 2008–19 (MBIE, 2017; NZTech & New Zealand Digital Skills Forum, 2021). The government provided funds (2014–19) to help set up ICT Graduate Schools to strengthen industry-focused education and research (Tertiary Education Commission, 2019; New Zealand Government, 2016). The review of the Digital Technologies curriculum and its extension to all students from year 1–13, the development of Digital Technologies Achievement Standards, and the replacement of all sub-degree computing qualifications in the New Zealand Qualifications Authority (NZQA) Framework with 14 new Diploma and Certificate qualifications all aimed to equip students with digital capabilities and solve the disconnect with industry needs (IT Professionals NZ, 2021).

Even so, industry stakeholders cite a mismatch between their needs and graduates' skills as one of their key challenges. The Digital Tech ITP progress report noted that many teachers do not currently have the skills to teach the new curriculum. Also graduates need both technical and soft skills, but not many qualifications teach both (MBIE, 2020a). Therefore, many graduates struggle to gain an internship or an entry-level job. The Digital Skills Aotearoa report (2021) documented the decreasing participation of high school students in technology courses and the risk of a workforce lacking diversity.

IT Professionals NZ argues that the industry expects fresh graduates to have all the needed knowledge and the skills to apply them. They call for changes in firms' culture and expectations and putting in place the systems, mechanisms and processes that allow the industry to invest in people, for example, through internships and apprenticeships (IT Professionals NZ, 2020). Some firms have told the Commission that they are taking a grip on this issue and starting to design more comprehensive induction training for fresh graduates. MBIE has been working with the Ministry of Education, the Tertiary Education Commission and industry representatives to design a pilot to help new employees bridge the gap to work-readiness (MBIE, 2020a).

A programme of note is Te Uru Rangi. It is a scholarship programme to help train the next wave of Māori tech, digital business leaders and entrepreneurs by offering hands-on training and career development. It is a collaborative partnership between Enspiral Dev Academy, Te Puni Kōkiri, NZTE and Callaghan Innovation (Te Puni Kōkiri, 2015).

While short courses (for example, in programming) and on-the-job training can help with the supply of entry-level skills, filling the more senior roles often requires bringing in skilled workers from overseas. Therefore, most industry stakeholders noted the direct impact of migration policies on their productivity. In the long term, Kiwis may be able to fill more of the senior roles as the industry grows and people gain more experience by working in various companies and roles across the industry. In the meantime, the industry relies heavily on migrants.

The number of work visas approved for IT services occupations almost doubled from 2011 to 2017 (from 3 225 to 6 087), but dropped to just over 4 251 in 2019 (MBIE, 2021). In addition to various suggestions to improve immigration settings, stakeholders were commonly concerned about Immigration New Zealand's operational efficiency.[21] They asked for a faster, more efficient immigration system because it takes a lot of effort and time for a firm to bring in a skilled worker. The firms suffer throughout the (work and residence) visa processing period, not only because of project delays, but also due to the uncertainties involved.

A common suggestion by stakeholders was for the Government to invest in branding New Zealand as a "tech centre".[22] Participants (from both the industry and government agencies) told the Commission that the New Zealand's brand has been bolstered due to the Government's comparatively effective management of Covid-19. While New Zealand is known for its association with Hobbits and as a holiday destination, people have started also to respect this country for its good leadership and the use of science and technology. Most stakeholders wanted the Government to capitalise on this opportunity and promote the country as a destination for talent.

A 2017 survey of industry stakeholders indicated that New Zealand's growing reputation as a technology centre is due to a combination of space, friendliness, good education, healthcare, ease of doing business, simple regulations and previous high-profile successes (MBIE, 2017). Attracting international talent also requires a dynamic ecosystem (with active, leading firms and top universities), as well as established digital infrastructure.

Post-Covid-19, both firms and skilled workers are more likely to consider remote working opportunities (The Economist, 2020). New Zealand may be a favoured immigration destination for remote workers, which could further help Kiwi firms to attract and work with international talent. It could put them on a more equal footing compared with competitor firms from larger countries. Even so, some interviewees noted that New Zealand's high housing costs might deter international talent.

5.4 Regulation of the sector

Software firms design, develop and maintain a broad range of computer systems for other sectors. Therefore, the legislation, regulation and policies of those sectors affect the Software industry. For instance, the Australian Productivity Commission and NZPC (2019) noted that policy initiatives (such as

[21] See NZTech's Briefing to Incoming Ministers (2020, p. 4) for a list of proposed actions to manage and fix the current immigration bottleneck.

[22] Branding New Zealand as a "tech centre" also helps firms sell their products and services overseas.

a consumer data right) "create opportunities for a stronger fintech sector", which is a vibrant subsector of the Software industry (p. 98).

Further, the industry not only collects, maintains and has access to personal information, but also produces products that enable other firms and organisations to collect and maintain personal data. Therefore, the Privacy Act 1993 and other privacy, confidentiality, data and cyber security legislation (for example, the secrecy of tax records under the IRD statute, 1994), regulations (for example, Data and Information Management Principles, 2011), policies (for example, Cyber Security Strategy, Digital Content Strategy and open data policies), and the common law of privacy torts (for example, Hosking v Runting, 2004) affect the operation and future of the Software industry.

As noted in previous sections, stakeholders also told the Commission that immigration policies, and market access and export promotion initiatives have significant impacts on the industry. APC and NZPC (2019) further noted the importance of cross-border consumer protection and global trade rules. They concluded that the government should set regulations to be nimble and technology-neutral to allow the industry to grow. New Zealand's light-touch regulation of the space sector is an example of innovation-enabling regulation.

A significant regulatory barrier

Access to consumer data is a critical barrier for FinTech companies. The Productivity Commission has previously recommended acceleration of policy work to establish open banking to allow customers to securely access information held by a bank about them and share that data with third parties (APC & NZPC, 2019). MBIE's recently published discussion document on the options for establishing a consumer data right (CDR) in New Zealand summarises stakeholders' views:

> [G]overnment intervention to promote more widespread secure data portability through a CDR… will help give consumers access to a wider range of products and services that better meet their needs by reducing barriers to sharing and use of data by trusted third parties. In turn, this will promote competition, innovation, economic development and good outcomes for consumers. (MBIE, 2020c, p. 25)

The Commission's frontier firms inquiry report examines in more detail the case for a CDR in New Zealand and makes findings and a recommendation (see Chapter 10).

5.5 Government is an important client

Government purchases 29% of ICT products and services supplied by New Zealand firms (NZTech, 2020). This strong purchasing power provides an opportunity for the government to promote innovation, and support software firms to further develop and showcase their systems. Selling products to the New Zealand government can be very helpful in attracting other local and overseas clients. Modern IT systems (such as SaaS and cloud-based products) can be configured to meet the needs of government departments, and provide them with cost savings.

Recent changes to the government's procurement rules should help local software companies gain a greater share of government contracts. One of the new procurement rules is to "increase access for New Zealand businesses" (Rule 17). Under this rule agencies must consider how they can create opportunities for local businesses when procuring for designated contracts, including computer software contracts. Creating opportunities for local businesses could involve working with them to achieve the next steps in the innovation process (for example, trialling new products to demonstrate viability). Procuring agencies must also conduct sufficient monitoring of designated contracts to ensure that commitments under the new rules are delivered and reported on (MBIE, 2019).

Yet industry stakeholders told the Commission that public procurement rules do not adequately encourage purchasing of new and innovative local products versus those from large foreign, brand-name companies. Industry stakeholders also told the Commission that government agencies are wary of off-the-shelf SaaS products due to their risks. It is possible some of this perception is due to the fact that the new rules and policies will take some time to bed-in, and for procurers to adopt different skillsets and mindsets. Agency monitoring and evaluation of whether the new commitments are being

met will be important to understand whether the new changes are working as intended. As noted in Chapter 6 of the frontier firms inquiry report, building capacity among both government procurement officers and companies will be crucial for these new rules to work.

Part three:

Insights & conclusion

Part three brings together the insights from the qualitative and quantitative research done on the case-study industries.

6 Insights

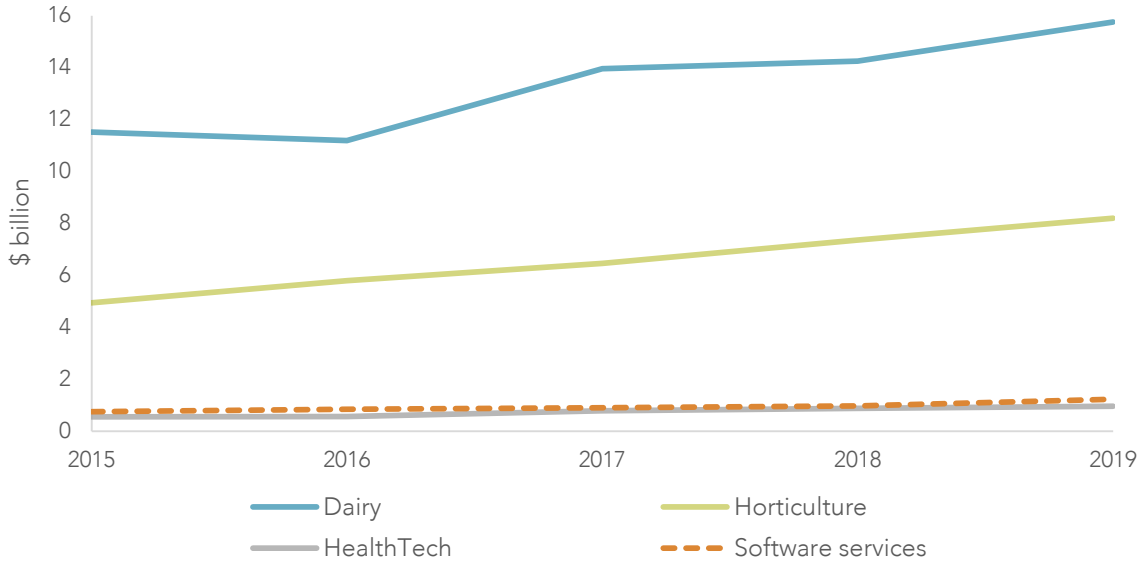
This section compares the case-study industries and discusses some of the insights that emerge and are relevant to the Commission's inquiry into frontier firms.

6.1 Frontier firms export more

Four significant exporting industries

The case-study industries were selected because they are exporting industries of significant size or with high-growth potential. Dairy is the biggest generator of export revenue of these industries, followed by Horticulture (Figure 6.1). Together these industries make up 30% of New Zealand's total exports.

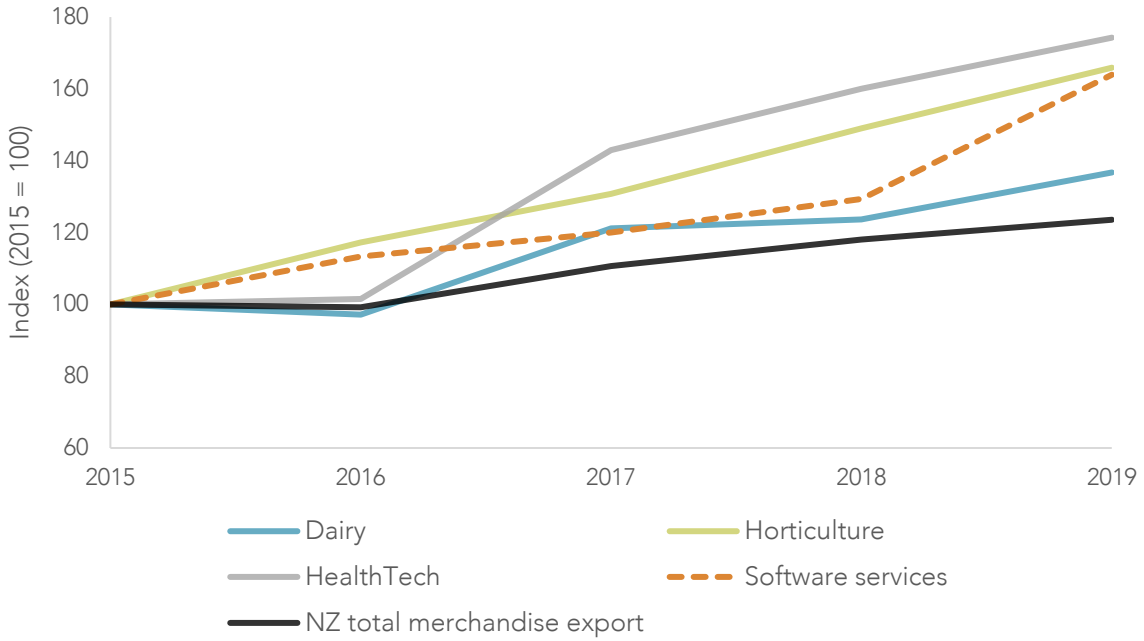
Figure 6.1 Value of exports (nominal, NZD billions), 2015–19



Source: Stats NZ, NZPC calculations.

Exports in all the case-study industries have been growing faster than New Zealand's total merchandise trade over the past four years. HealthTech has grown most strongly, followed by Horticulture and Software (Figure 6.2).

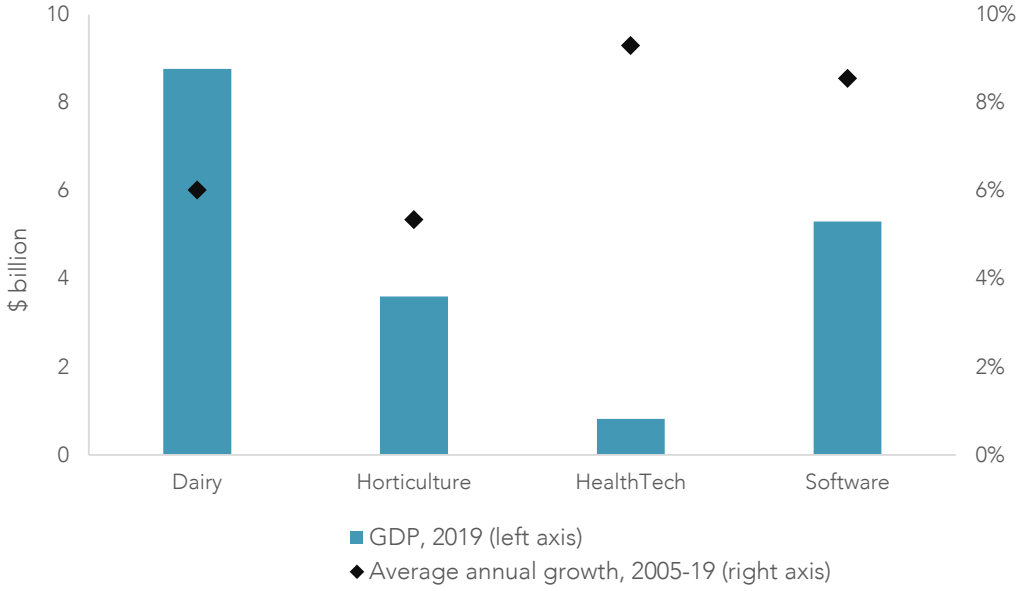
Figure 6.2 Growth in exports, 2015–19



Source: Stats NZ, NZPC calculations.

Dairy makes the largest contribution to GDP (Figure 6.3). The contribution to GDP by the Software industry outstrips that of Horticulture, due in part to higher domestic sales and also higher value-added (profits and wages) as a proportion of revenue. HealthTech has grown its contribution to GDP the fastest over the 14 years, with Software close behind. It is important to note that each industry's contribution to GDP goes beyond this through the inputs they use and where other industries use their products to develop other products. For example, Dairy and Horticulture use transport services and Software is used by businesses throughout the economy.

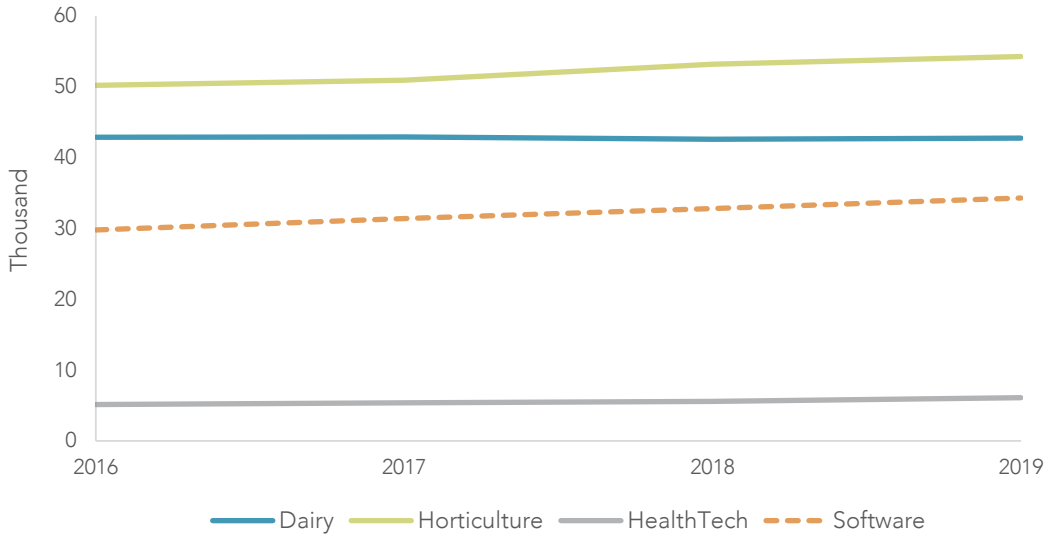
Figure 6.3 Contribution to, and growth in, nominal GDP



Source: Stats NZ, NZPC calculations.

Figure 6.4 shows that Horticulture makes the biggest contribution to employment, although not all this employment is permanent. Employment in Software is catching up with that in the more capital-intensive Dairy industry. It is worth noting this only includes employment in the Software industry, not people with similar skills working in other industries.

Figure 6.4 Number of employees by industry, February 2016–19



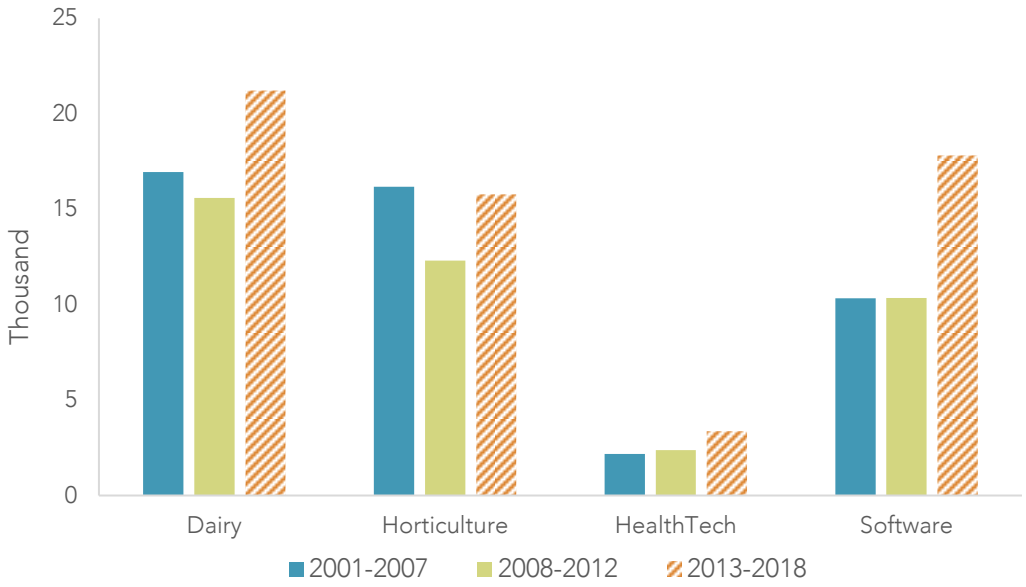
Source: Stats NZ, NZPC calculations.

Notes:

1. The figure presents the number of paid employees in February each year based on Business demography statistics. This data set includes working proprietors who pay themselves a wage.
2. The Horticulture industry typically has a high number of seasonal workers in February.

Adjusting for FTE employment brings down the Horticulture total and shows the rapid rise in Software employment.

Figure 6.5 Fulltime equivalent employment by industry, 2001–18



Source: Stats NZ, NZPC calculations.

Notes:

1. The figure presents average FTE employment in each time period, based on Linked employer-employee data (LEED).
2. This data set does not present the same total employment as Figure 6.4 because it is FTE employment and it excludes some very small firms (see section 1.4, LBD data). It also covers a different time period.

Frontier firms export more than non-frontier firms

A major conclusion of the Commission's frontier firms inquiry report is that reaching the global productivity frontier requires a firm to invest in innovation. For firms in countries like New Zealand, with

a small domestic market, exporting is key to unlocking the scale necessary to generate the returns required to justify that investment.

The data analysed for these case studies gives a further insight. The data show that, among firms that export, frontier firms export far more than non-frontier firms. For all industries except Dairy, frontier firms – the top 30% of firms – contributed around two-thirds of the industry's total exports.[23] This reinforces the importance of frontier firms in an SAE and is consistent with the findings of other research undertaken for the inquiry (Fabling, 2021).

6.2 Hurdles to internationalisation vary, as do industry responses

Across the case studies, hurdles to internationalisation vary by industry and destination market, a result that is consistent with the findings from text-mining of NZTE data (Sim et al., 2021). This is unsurprising, as countries have different legal and regulatory systems (including tariff and non-tariff barriers), as well as different institutions, cultures and languages. Different industries are also regulated differently.

Small firms in Dairy and Kiwifruit (a subsector of Horticulture) have overcome exporting hurdles by acting collectively through large export bodies (for example, Fonterra and Zespri). This means that their products can get to market efficiently. However, these industries face capacity constraints that could temper future export growth (see section 6.3).

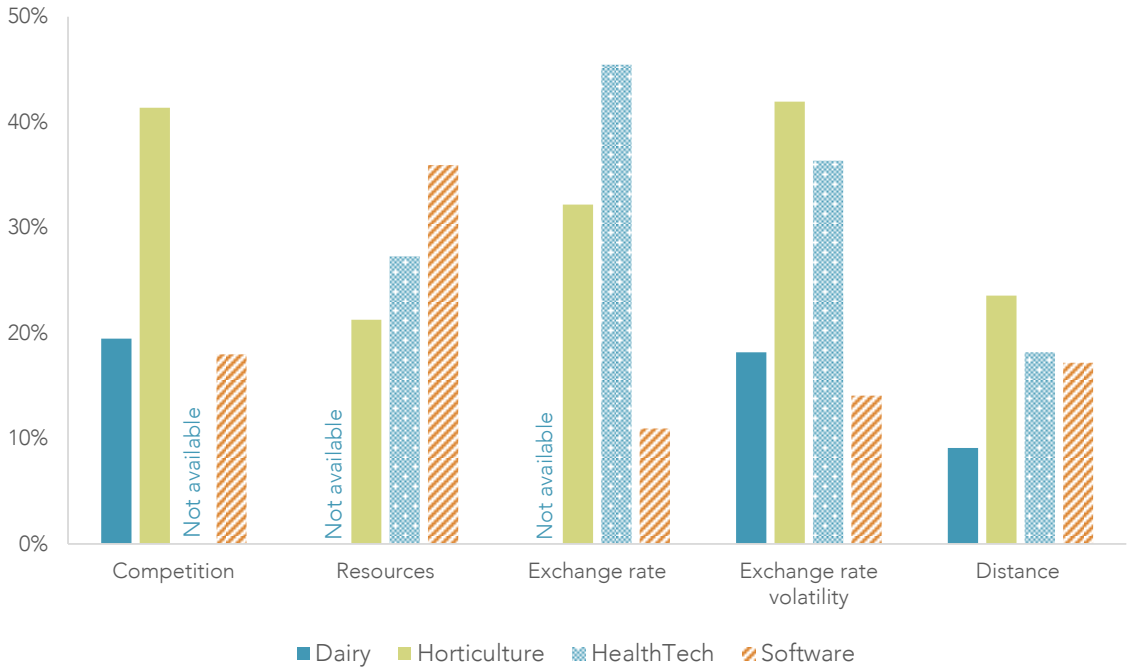
The Wine industry has several large companies that have scale. These large and mostly multinational companies export wine in bulk through global value chains. Some tensions exist between these large firms, and smaller, more artisanal firms concerned with maintaining their price premium and brand narrative.

An advantage of weightless industries like HealthTech and Software is that they face lower barriers to getting their products to market – a feature that is very relevant to a small, distant economy like New Zealand where commodity firms face high costs of transport to export markets. Also, once weightless products are developed, they tend to have low marginal production costs compared to the value of the item, leading to high profit margins on each product unit. The one exception to this point is the regulatory hurdles faced by HealthTech companies.

Software firms exhibit very different export patterns than other case-study industries. A high proportion of firms are engaged in exporting, yet exports make up a relatively small proportion of their sales. Software firms also report different barriers to exporting as can be seen in Figure 6.5. Horticulture, Dairy and HealthTech firms were all more likely to report factors like exchange rate volatility as a key barrier to exporting, whereas Software firms were more likely to report resource constraints (including managerial time) as a barrier. Analysis of NZTE data also suggests Software firms can face barriers around language when entering new markets (Sim et al., 2021).

[23] Dairy exports predominantly come from a small number of processing firms. Even within that small set, Fonterra dominates. Accordingly, Fonterra's position in the productivity distribution has a major influence on the proportion of exports that come from frontier firms in dairy.

Figure 6.6 Barriers to exporting (% of firms in each industry), 2015



Source: Stats NZ, NZPC calculations.

Note:

1. The figures for proportion of Dairy firms reporting resources and exchange rate, and HealthTech firms reporting competition, as barriers to exporting are suppressed due to confidentiality.

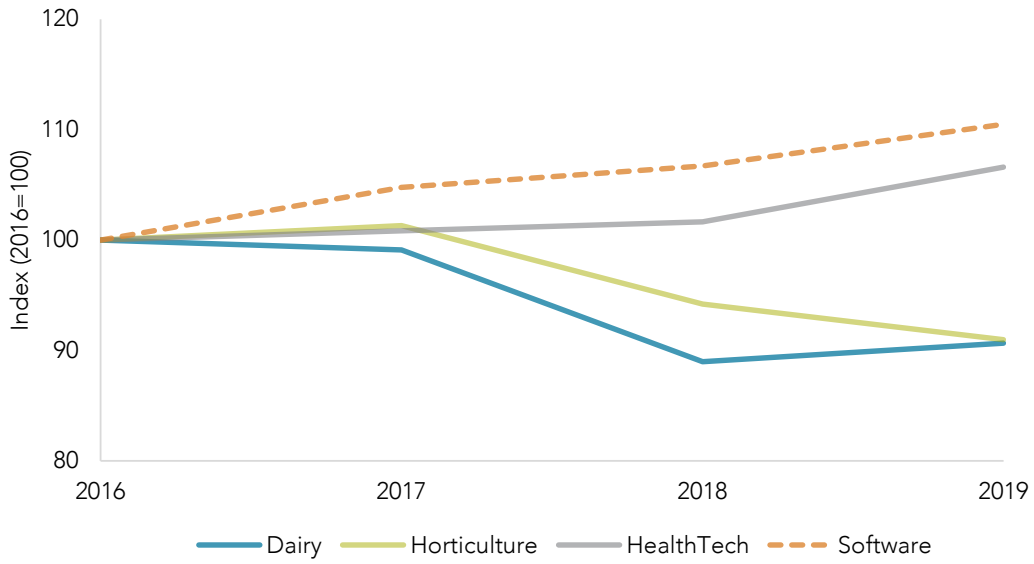
For context, New Zealand's high and volatile exchange rate is in part due to the country's historical reliance on commodities that tend to have higher swings in prices over time than manufactured goods (Steenkamp, 2014). This adds to the challenges of the country's small size and distance from other markets, which themselves make it more difficult to export specialised, distinctive, high-value products at scale (Simmons, 2002). New Zealand firms are likely to be smaller when they start exporting – due to the small domestic market – and so are more vulnerable to competition pressures and a volatile exchange rate (Skilling, 2001). As a result of these pressures, most manufactured goods exported from New Zealand tend to be in niches where there is sufficient market to warrant operating, but not intense competition from large foreign firms. So, a business may see the exchange rate or competition as a problem, but these could be symptoms of a deeper problem – New Zealand's small domestic economy and distance from markets.

Given these challenges seem to be less of a problem for Software firms, the Software industry may be living up to the promise of IT reducing the disadvantages of New Zealand's small size and distance from markets. This may also help explain why, according to Zheng et al. (2021), the ICT sector is one area in which New Zealand is closing in on the SAE productivity frontier (section 5.1).

6.3 Consolidation and constraints to growth

The number of firms in Dairy and Horticulture is falling, while the numbers of Software and HealthTech firms continue to rise.

Figure 6.7 Change in number of firms, 2016–19



Source: Stats NZ, NZPC calculations.

This consolidation in Dairy and Horticulture firm numbers reflects large corporate farmers/growers taking over small holdings. Larger units can run more efficiently because of scale economies in areas such as milking, harvesting, and processing. For industries like wine, the activities of marketing and distribution also exhibit economies of scale.

As noted in sections 2 and 4, Dairy and Horticulture also both face constraints such as environmental limits, and the availability of suitable land and labour (based on current labour-intensive harvesting methods). These constraints emphasize the need to focus on productivity growth through automation, developing premium products and contining to innovate across the production chain.

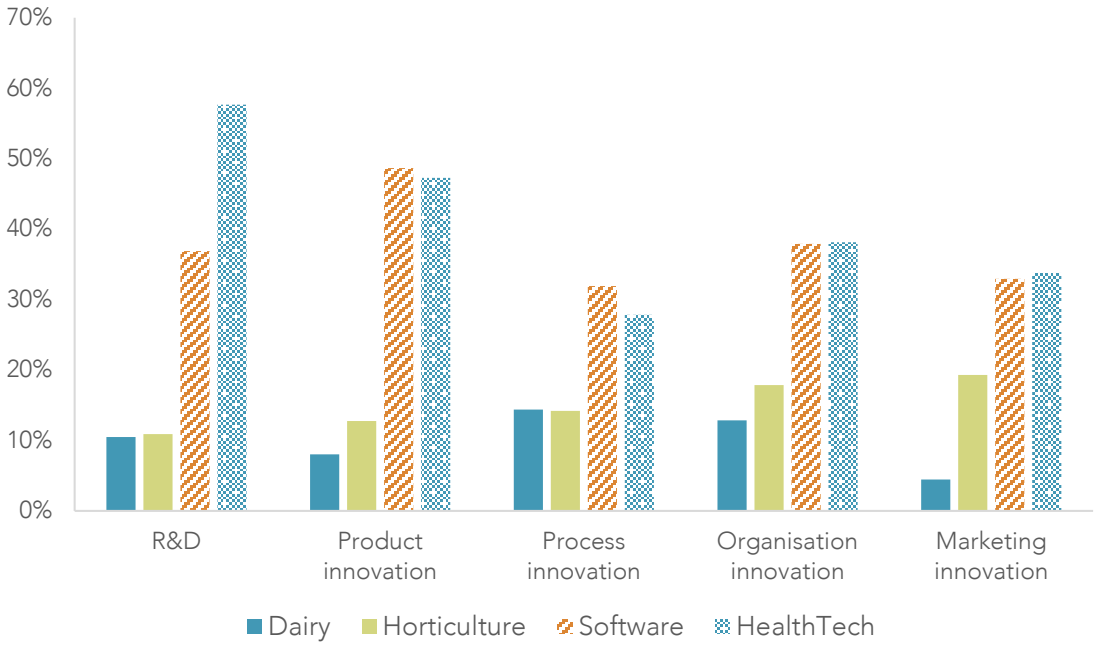
HealthTech and Software, in contrast to Dairy, kiwifruit and wine, do not face land or environmental constraints. For these industries, the lack of skilled labour is a key barrier (section 6.8).

6.4 Innovating to create specialised, distinctive products

Innovation is crucial for developing specialised, distinctive, high-value products, which is in turn reflected in improved productivity. Section 4 showcased the importance of innovation in the kiwifruit industry in creating the SunGold™ variety and avoiding a repeat of the "commodity trap" that occurred with green kiwifruit. Both Dairy and wine (sections 2 and 4) face risks of commodity traps, which makes ongoing innovation in those industries even more important.

The advantage of weightless industries (such as HealthTech and Software) can be seen in Figure 6.8, which shows the self-reported rates of innovation in firms in each industry. It is important to note that firms in kiwifruit (making up a large proportion of Horticulture(and Dairy rely heavily on their large cooperatives to invest in R&D, product innovation and marketing innovation so it is understandable that their innovation rates are lower. Even so, rates of process and organisation innovation are also higher in the weightless industries.

Figure 6.8 Rates of R&D and innovation (% of firms in each industry)



Source: Stats NZ, NZPC calculations.

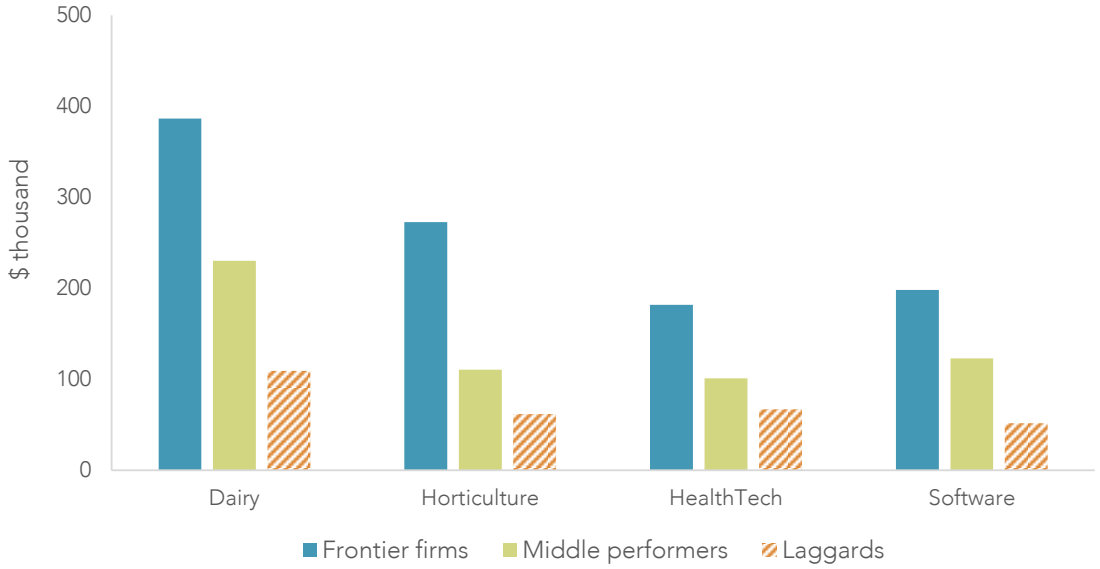
6.5 The growing importance of intangible assets is creating different industries

Intangible assets are associated with higher skills and higher wages

As discussed in section 5.2, the weightless industries of HealthTech and Software illustrate the growing importance of intangible assets. Tangible assets include things like machines and land, which can generally be redeployed more easily to other industries. Intangible assets involve things like IP and software code, which cannot be physically touched and are often specific to the industry or even the firm itself. Tangible assets are much easier to value and therefore are picked up in capital-stock statistics, whereas intangibles are often overlooked (at least until a company is large).

Across the case studies, labour productivity seems to be the highest in the Dairy industry, particularly for frontier firms. Software has the highest wages of the four case-study industries. In both labour productivity and wages, the other industries are quite similar.

Figure 6.9 Average labour productivity, 2013–18



Source: Stats NZ, NZPC calculations.

Note:

1. Labour productivity is measured by real value-added per FTE.

Figure 6.10 Average wages, 2013–18

Source: Stats NZ, NZPC calculations.

Significant differences typically occur between labour productivity and wages because value added is made up of both wages and returns to capital and other factors such as land. But the differences can vary across industries.

In Dairy, high labour productivity reflects not only technology, but dairy workers using high levels of other inputs that make them more productive – land and machinery in the case of farming, and large factories in the case of processing. The productivity of dairy firms at the upper end of the productivity distribution (the top 30% of firms) was around 3.5 times that of firms at the lower end (the bottom 30% of firms). Horticulture is similar in the high levels of tangible capital involved.

Software has lower labour productivity but higher wages. This likely reflects the highly skilled labour employed in this industry, the scarcity of those skills and comparatively low rates of tangible capital. Skilled labour is often employed to build up levels of intangible capital, for example, in the form of code for Software or R&D for HealthTech. Therefore, in their start-up and growth phases, companies in these industries will have high costs and low revenues, so having low measured productivity. This upfront investment in intangible capital is likely to boost the productivity of companies in these industries as they mature.

Intangible assets generate different financing needs

The growth of industries that rely on intangible over tangible assets is creating large shifts in how economies function (Haskel & Westlake, 2018). For example, the finance needs of companies and their access to finance are very different, depending on whether they use tangible or intangible assets. Dairy and Horticulture are both land-based, with land being among each firm's largest assets. Land is easily transferable to other uses and has a relatively stable value, so can be used as collateral for loans to purchase land and other assets. It is no surprise that land-based industries (agriculture and accommodation) dominate bank lending to business.

By contrast, industries with high levels of intangibles (such as Software and HealthTech) cannot finance their companies with debt finance to the same degree. As a result, they tend to rely much more on equity financing for early-stage finance and growth. In new industries it can take time to build up a supply of "smart capital" (with knowledgeable and specialised investors) for businesses that are looking to scale. Revenue-based financing is emerging as a new tool for businesses overseas and could prove useful in financing growth for businesses with intangible assets in New Zealand.[24]

6.6 Cooperatives have both challenges and opportunities to innovate

Dairy has struggled to add value through innovation

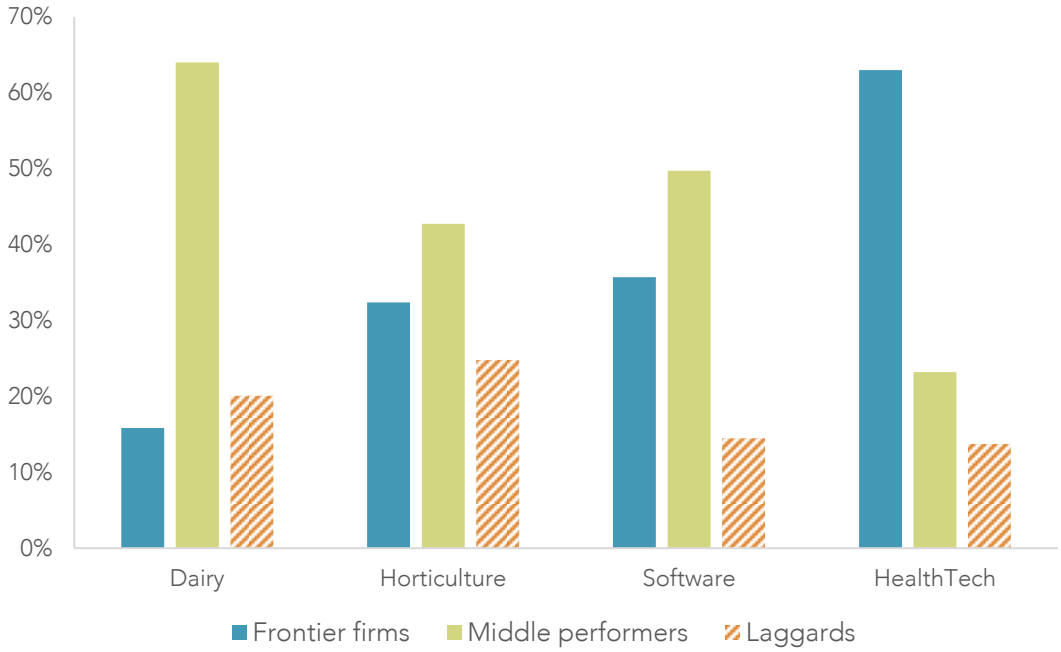
Economists expect resources (such as labour and capital) to flow from low productivity firms to high productivity firms. In that way, better performing firms grow, and poorer performers shrink and may even disappear. This is one way that the productivity of the total economy rises as resources find more productive uses.

Figure 6.11 shows the proportion of the labour force employed by the frontier firms in each industry compared with middle productivity performers and laggards. HealthTech's distribution is closest to what we would expect to see from a well-functioning industry. As noted in section 4, Horticulture may be some way from the optimum labour allocation. Software has relatively low barriers to entry and a lot of new start-ups, so many companies may be less productive because they are still in their early stages of growth and have not yet generated revenue.

Dairy deviated most from a desirable allocation of labour. The Commission's analysis found that while resource allocation has improved over time for Dairy, the industry was still looking in 2013–18 some way off an "optimal" resource allocation with frontier firms attracting most labour and capital.

[24] Revenue-based lies between debt and equity financing. There are no interest rates but in exchange for finance companies are expected to offer a proportion of future revenue up to a multiple of the original loan.

Figure 6.11 Share of labour across productivity groups, 2013–18



Source: Stats NZ, NZPC calculations.

Resource allocation in Dairy is likely to reflect the varying performance of Fonterra because it is such a large part of the industry. In addition, resources may be relatively slow to move between firms in the Dairy industry because of Fonterra's cooperative structure. Fonterra controls roughly 80% of New Zealand's milk supply and, as noted in section 2, it has struggled to add value to its products. In the past it has been hampered by having to accept milk from all new dairy conversions and farmer suppliers. A recent reform of DIRA has removed this obligation but, in doing so, it may slow the reallocation of resources by discouraging farmers from supplying new processors.

Zespri has shown how cooperatives can work

The cooperative model is not in itself bad. Rather, the devil is in the detail of how a cooperative model works. This is illustrated by the small but successful dairy cooperative, Tatua, and the example of Zespri in Horticulture. Kiwifruit makes up 40% of horticulture exports and its Zespri cooperative is a single-desk exporter and marketer.

As discussed in section 4, Zespri and its partners have been very successful at investing in innovation and adding value, mainly through new varieties of kiwifruit. Zespri charges licence fees and royalties on growers using cultivars that it owns. Some of this money is used to invest in more innovation. A feature that has distinguished kiwifruit and dairy is that Zespri can control the entry of new growers through licensing. This is a lever that Fonterra has only recently acquired. Zespri controls entry to constrain supply, improve quality and maintain price premiums.

Kiwifruit growers – the owners of Zespri – are more open to investing in innovation. They have seen the successes of past investments (and learnt from past crises), creating a virtuous cycle that supports further investment. By contrast, dairy farmers seem to prefer Fonterra to deliver the maximum price for their milk solids now rather than investing in innovation that could increase their returns long term. This difference may be cultural, or it may be related to the past performance of Zespri and Fonterra. Zespri has shown growers it can provide a return on their investments in innovation.

This narrative illustrates the need to strike a balance between competition and cooperation, otherwise known as "co-opetition". Being a small economy distant from global markets means that there are potential gains to be made from working together to get the scale necessary to break into export markets, as dairy farmers and kiwifruit growers do via their cooperatives. Most New Zealand exporting

businesses are not direct competitors with each other, and even collectively are "small" in international markets, so there is little risk of harmful collusion.

Accordingly, there may be gains to the country from exporting companies working together more. Yet too much cooperation risks putting of all an industry's eggs in one basket. Then when that basket performs poorly, it has adverse consequences for the country – as has been seen from time to time with world dairy prices and Fonterra.

An important perspective on cooperatives is provided in a paper by two New Zealand economists (L. Evans & Meade, 2005). They observe that cooperatives are often argued to provide inferior financial performance compared to Investor-Owned Firms (IOFs), or be relatively inefficient. They find that the weight of evidence about cooperative performance relative to IOF performance does not support such claims. Therefore, the mere existence of cooperatives in an industry cannot be taken to mean that the industry's performance is being hampered.

Having relatively homogenous products is important to the success of cooperatives. The variety of products in the HealthTech and Software industries mean that there is less scope to use cooperative models to band together as individual producers in Dairy and Horticulture do. For example, it would be more difficult to find economies of scale in things like innovation and distribution (exporting) in HealthTech and Software.

6.7 The impacts of Covid-19 have varied across industries

Covid-19 has had a huge impact on the global economy, particularly outside countries like New Zealand where the virus has been largely contained. The country has largely felt the impact of Covid-19 through its impacts on exporting firms and industries like tourism and export education. The impacts on the case-study industries have been varied.

A notable impact has been on the HealthTech firm Fisher & Paykel Healthcare. Its humidifier/respirator products have fortuitously proven perfect for easing the symptoms of severe Covid-19. Sales have soared, driving a 37% increase in profitability in the 2020 financial year. Results for FY2021 are even more promising, with operating revenue up 73% in constant currency terms by 31 December 2020. The company's share price has almost doubled since the onset of Covid-19.

The longest-lived impact of Covid-19 may be the increase in remote working, which has been a game changer for Software firms. Remote working has increased the demand for cloud-based platforms (such as provided by accounting software firm Xero) so that businesses and individuals can access their information from anywhere. Also, demand for gaming software has notably increased (Mitchell, 2020).

The rise in remote working also creates an opportunity for New Zealand to attract skilled migrants. The country is stable, virus-free, has good high-speed broadband and a great lifestyle for those that can work from anywhere. So far, a lot of skilled Kiwis have returned home, and the country has enjoyed a big boost to its overseas reputation. It remains to be seen whether these benefits continue once the rest of the developed world is vaccinated. The lack of affordable housing will also be a challenge for prospective migrants, and it will put some off.

The global demand for food has tended to remain strong during the pandemic, yet there have been winners and losers. With hospitality around the world either shut down or severely impaired by the pandemic, growth areas have been home cooking and supermarkets (Consultancy.uk, 2020). Businesses that usually service restaurants have been hit hard, for example, high-end wine producers. Some high-value products (such as a2 Milk) have also suffered.

6.8 Shortage of highly skilled labour is a key constraint

All four industries reported difficulties in recruiting highly skilled labour, particularly people with advanced research skills. Research institutions told the Commission that they source a significant proportion of their workforce from overseas, as New Zealand universities are not supplying the numbers or types of postgraduates they need, including via postdoctoral programmes.[25] Shortages exist not only in traditional core science subjects, but also in the wider skill mix that modern industry-facing researchers require including data science, commercial and business skills, and soft skills such as communication.

Software firms reported a lack of more experienced people with suitable skills (for example, product managers and international marketing experts), as well as skills mismatches at entry level. Horticulture firms reported difficulty recruiting marketing skills. A shortage of Māori graduates and workers in STEM (Science, Technology, Engineering & Mathematics) was highlighted by several stakeholders in the food industry more broadly. These signs of mismatch suggest that the New Zealand's education system is not delivering the skills required by industry, including at entry level.

Lack of management skills is a key barrier to exporting and innovation. The Commission's analysis of BOS data and its interviews suggest these issues are especially prevalent in the growing Software and HealthTech industries. Chapter 9 of the Commission's frontier firms inquiry report discusses the importance of building management skills to support productivity growth.

6.9 No firm is an island – innovation ecosystems are critical

The term "innovation ecosystem" is not part of the common business lexicon, at least not in New Zealand. It is used in innovation policy circles, particularly in small, advanced economies. Despite this, a consistent message from interviews with industry stakeholders was the importance of their innovation ecosystems. Some spoke of the networks between firms. Others spoke of the networks between firms and research organisations. On occasion they mentioned relationships with government agencies.

New Zealand's exporting businesses seem to understand intuitively the importance of networks for gaining scale. The challenges of having a small domestic market and being distant from large foreign markets are ever-present. Working together is one way to get the scale that most companies lack. This should not be a concern from a competition perspective. New Zealand's exporting firms are generally not competing with each other, as they are niche players in the global marketplace.

Innovative businesses clearly value their innovation ecosystem, regardless of whether government is involved or not. Yet interviewees consistently mentioned that New Zealand firms are not generally good at cooperating. New Zealand policymakers have contributed to this by undervaluing the importance of well-performing innovation ecosystems.

The BOS data showed that for firms in all four industries, innovative ideas were most likely to come from staff, networking events, customers (except for Dairy), suppliers and competitors. By comparison, the publicly funded innovation ecosystem players in these industries were a less common source of new ideas. CRIs, universities (both in New Zealand and overseas), polytechs and government rated comparatively poorly as sources of innovation for all the industries, except HealthTech. HealthTech firms were substantially more likely to get their innovation from CRIs, domestic universities and overseas universities.

The lack of good links between researchers and businesses is a common feature in New Zealand industries. Improving these links will be crucial to boost innovation, as discussed in Chapter 6 of the Commission's frontier firms inquiry report.

[25] A postdoc is a fixed-term position that allows a PhD graduate to continue to build their skills and experience through further research.

The case-study industries have quite different innovation ecosystems, mostly because of different histories rather than deliberate industry strategies. In each industry, an ecosystem exists and exerts a powerful influence on the performance of the innovating firms in it. Each of the ecosystems has its own challenges and opportunities. HealthTech, Horticulture and Dairy all have large and complex innovation ecosystems. A lot of the complexity comes from the proliferation of government support in these industries.

Software's innovation ecosystem is quite different, being almost entirely led by the private sector. With no dedicated CRI or CoRE, most of the innovation happens within firms themselves. Despite this relative lack of support, the industry has consistently managed to be innovative, and grow revenue, exports and employment while maintaining high wages.

Kiwifruit's innovation ecosystem demonstrates the value of research partnerships and arrangements that disseminate best practice, control quality and protect the industry's IP (Box 11).

Box 11 **Kiwifruit demonstrates the value of IP protections and research partnerships**

The story of kiwifruit illustrates the vital roles of IP protection and of long-running research partnerships.

Things were not always so golden

New Zealand was the first country to commercialise kiwifruit. However, despite establishing the first successful commercial cultivar (the green Hayward variety) and the name "kiwifruit", neither were protected by a PVR or a trademark. This allowed increased production in competitor countries in the 1980s, and the subsequent global oversupply and price crash. A raft of other international and domestic challenges hit the industry, including the enforcement of Maximum Residue Levels for pesticides in European trading partners, and rises in the New Zealand dollar and interest rates (Campbell, 2018).

In 1987, a kiwifruit producer board was formed as a "single-desk" buyer of New Zealand kiwifruit, to replace the competitive model of the Kiwifruit Authority. An Industry Review in 1993 then resulted in the industry being completely re-shaped. Major changes included: grower control of the industry and its IP; grower-directed marketing and research; the creation of a new single brand and single-desk marketing entity (Zespri); the development of new consumer-driven varieties; and a new approach to crop and orchard management, emphasising environmental sustainability (now known as the Zespri System).

In 2015, 97% of growers supported the single-desk model (NZKGI, 2019). This model helps provide certainty to support a long-term investment horizon, focused on future market trends.

By licensing growers, Zespri controls the supply of New Zealand-grown kiwifruit for which it owns the PVRs (for example, the SunGold™ variety). It also retains exclusive rights to export New Zealand-grown Green kiwifruit to all countries other than Australia, as well as its own cultivars. Zespri releases new licences for a limited number of additional hectares of its PVR-protected varieties to be grown each year, to ensure the industry avoids the commodity trap of the past. Instead, it makes sure to build demand ahead of supply. Kiwifruit's success is also underpinned by consistently high quality delivered across the industry. Zespri has developed reliable measures of ripeness, quality and taste, which signal optimum harvest times and enable differentiated payments to growers. Growers can only harvest when testing shows their fruit has reached the required taste, ripeness and food safety standards. Zespri also places strong emphasis on quality control, including post-harvest in logistics and supply chains. All these underpin its reputation for quality and the price premium it can command.

Another key driver of success is the creativity and open innovation model that operates among New Zealand growers. This can take a new, protected variety, and quickly develop and share best growing and vine management practice across the industry.

The transformation of the kiwifruit industry represents "a textbook case of how to turn a worthless food commodity into a high-value product" (Campbell, 2018, p. 88).

A long-running research partnership has been critical

The development of the Zespri SunGold variety has played a critical role in the industry's transformation. Its development came out of significant investment in research by both the industry and government over two decades, successful commercialisation (including marketing and investing in a strong brand) and robust IP protection. A critical component was intensive investment in gaining insights about consumers ("What will consumers want in 10 years' time?") and working back from there to find varieties that work on-orchard and through the supply chain.

Zespri has a key long-running research partnership to develop new cultivars with the CRI, Plant & Food Research (and its predecessor organisation, HortResearch). The ongoing research into new varieties fortuitously resulted in a major additional benefit to the industry. The Zespri SunGold variety, developed before the Psa disease struck the industry in 2010, turned out to be tolerant to the disease and saved the industry from collapse. SunGold accounted for around 44% of the crop by volume in 2019–20, with an average orchard-gate return to growers of $161 660 per hectare, compared to $67 295 per hectare for the non-PVR Green variety (Zespri Group Ltd, 2020a).

Zespri is likely at or close to the global frontier

The industry set-up of Zespri, its systems and the innovation model are likely at the global frontier or close to it, although it has few international counterparts. Zespri performs many of the roles that large firms typically play in industry clusters. It helps generate and protect the intangible assets of the industry, acts as an anchor for the myriad of growers and other supporting firms (such as post-harvest operators), and provides sufficient scale for the industry to be at the global frontier in productivity.

Zespri's approach to innovation and diffusion, underpinned by a strong customer focus and long investment horizon, provides key lessons for other industry organisations. Having Zespri invest on behalf of the whole New Zealand industry over decades allows the large and long-term investments required to develop new cultivars. Zespri also has the scale to invest in protecting and defending the industry's IP.

The industry's two "near-death experiences" of the price crash and Psa appear to have galvanised it. Industry stakeholders told the Commission that these events contributed to cooperation across the industry, and to the drive to maintain quality and price premiums. Future success will require ongoing innovation in the breeding programme, including new cultivars that can pick up from Zespri SunGold when its New Zealand IP protections expire in 2039.

A workable solution must also be found to address unauthorised SunGold kiwifruit plantings in China, which are now thought to cover around 4 000 hectares (compared to 8 000 hectares in New Zealand). Zespri considers the main threat to be from good-quality fruit, which could compete with New Zealand fruit and lower prices (as opposed to poor-quality fruit that could tarnish the brand). While the Chinese government recognises New Zealand's PVR ownership, taking proceedings against growers in rural China is difficult (Hutching, 2019; RNZ, 2020).[26]

[26] Zespri has been seeking a "win–win" approach to the issue, However, at the time of writing, Zespri's proposal to enter a trial commercial relationship with a Chinese state-owned company had been rejected by Kiwifruit NZ (the regulatory body for the industry in New Zealand). The arrangement would have involved Zespri buying and branding unlicensed kiwifruit from Chinese growers. The proposal is being reworked before seeking approval from Kiwifruit NZ and New Zealand growers (Manch, 2021).

7 Conclusion

The Commission undertook the research described in this working paper to inform its inquiry into frontier firms. It chose the case-study industries to get "under the hood" of the New Zealand economy and understand the performance of frontier firms at a more granular level. The four industries studied are all exporting industries of significant size or with high-growth potential, with the ability to help materially "shift the dial" on New Zealand's aggregate productivity.

7.1 The four industries illustrate the contrast between traditional and weightless industries

Dairy and Horticulture represent two more traditional, commodity-based industries, which have historically provided the bulk of New Zealand's export revenue. Their relatively higher productivity reflects their high levels of tangible capital.

The Dairy industry gains the scale needed to compete on the world stage through its cooperative Fonterra, which is New Zealand's largest firm. Past growth in the industry has come from increased volume. However, environmental limits mean future growth must come from a shift to products with higher value added. Achieving this will require greater investment in innovation, to get more value from a given volume of milk.

The Horticulture industry is dominated in value terms by kiwifruit and wine. Zespri, the cooperative of kiwifruit growers, acts as an anchor firm by generating and protecting the intangible assets of the industry and providing sufficient scale for the industry to be at the global frontier. Zespri's approach to innovation and diffusion, underpinned by a strong customer focus, smart branding and a long investment horizon, provides a model for other industry organisations. The relationship between the CRI Plant & Food (and its predecessor entities) and Zespri has been instrumental in developing innovative and high-value new fruit varieties. The success of this relationship demonstrates how government can support innovation through stable, longstanding research partnerships and funding.

Despite strong export growth potential, dairy, kiwifruit and wine are all facing challenges, including capacity constraints and the ongoing need to maintain and build market niches. This accentuates the need to focus on productivity growth through premium products and continued innovation.

HealthTech and Software provide a contrast to the two traditional industries. These more weightless industries generally face lower barriers to exporting, and have higher wages and higher rates of innovation. Measured labour productivity is lower, mainly because productivity in Dairy and Horticulture is boosted by the large amounts of land, equipment and other capital assets that are used in these primary industries.

The success of HealthTech has been driven by its anchor firm, Fisher & Paykel Healthcare. The industry's export revenues are growing fast, despite firms facing significant regulatory hurdles to entering new markets. The industry's innovation ecosystem appears to be functioning well. This may be due to its small size, high levels of training and research funding, and the involvement of the MedTech CoRE.

The Software industry has been growing strongly, both in the domestic market and in exports. Over the last decade, the number of firms has doubled and employment has tripled. It has the highest wages out of the four case-study industries, and there are some indications that Software firms face lower barriers to exporting than the other industries. The industry receives relatively little direct government support for innovation, and some industry stakeholders reported deliberately avoiding public sector support. However, the industry has benefited from the rollout of ultra-fast broadband. This is an example of indirect government support for innovation through a major infrastructure investment that has provided a basic building block for this and other weightless industries to flourish in a small and remote country.

The main constraint to continued growth in both these weightless industries appears to be the supply of suitably skilled labour.

7.2 The case studies indicate how government supports for innovation can be improved

This work has also revealed ways in which government supports for innovation and exporting could be improved – both at a system-wide level and in specific ways for particular industries.

At a system level, industry stakeholders across all four industries told the Commission that the suite of government programmes to assist firms with innovation and exporting is cluttered and confusing, with both gaps and duplication. The Commission makes recommendations for improving the coherence and accessibility of these supports in Chapters 5 to 8 of its frontier firms inquiry report. Firms in all industries also struggle to find suitable skills, including advanced research skills and management skills. Chapter 9 of the inquiry report makes recommendations for tackling these problems.

Chapter 10 of the inquiry report makes recommendations for easing regulatory constraints on innovation identified through the case studies. Some of these recommendations are industry-specific (such as around the regulation of Fonterra and the mandate on DHBs to participate in local innovation). Others have broader scope (such as around the regulation of GM and CDRs).

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Appendix A Level-4 ANZSIC industries

Dairy

A0160	Dairy Cattle Farming
C1131	Milk and Cream Processing
C1132	Ice Cream Manufacturing
C1133	Cheese and Other Dairy Product Manufacturing
F3603	Dairy Produce Wholesaling

Horticulture

A0121	Mushroom Growing
A0122	Vegetable Growing (Under Cover)
A0123	Vegetable Growing (Outdoors)
A0131	Grape Growing
A0132	Kiwifruit Growing
A0133	Berry Fruit Growing
A0134	Apple and Pear Growing
A0135	Stone Fruit Growing
A0136	Citrus Fruit Growing
A0137	Olive Growing
A0139	Other Fruit and Tree Nut Growing
C1140	Fruit and Vegetable Processing
C1214	Wine and Other Alcoholic Beverage Manufacturing
F3605	Fruit and Vegetable Wholesaling

HealthTech

C1841	Human Pharmaceutical and Medicinal Product Manufacturing
C2412	Medical and Surgical Equipment Manufacturing

Software Products and Services

M7000	Computer System Design and Related Services

Appendix B Interviewees

The Commission interviewed people from the following organisations, as well as some people in an individual capacity.

Apata Group Ltd
ARANZ Medical
Auckland Bioengineering Institute
Auckland UniServices
Bank of New Zealand
Biofarm
Biosecurity New Zealand
Bostock New Zealand
Bragato Research Institute
BusinessNZ / ExportNZ
Callaghan Innovation
Cemplicity
Canterbury District Health Board
Caroline Saunders
Centrality Ventures and Partnerships
Commerce Commission
Coriolis
DairyNZ
Datacom
David Tanner
Eastpack
Eight360
Fisher & Paykel Healthcare
Fonterra
Food HQ
FoodSouth
Frank Siedlok
Google
Gorgian Partners
HealthIT Consulting
IBM
Inland Revenue
Keith Woodford
Kiwi Landing Pad
KLIMA
Kyle Ford
Malcolm Bailey
Marcel van den Assum
Mark Paine
Ministry for Primary Industries
Ministry for the Environment
Ministry of Business, Innovation and Employment
Ministry of Health
MOVAC
National Science Challenge - Science for Technological Innovation
New Zealand Apples & Pears
New Zealand Game Developers Board
New Zealand Growth Capital Partners
New Zealand Health IT
New Zealand Kiwifruit Growers
New Zealand Trade and Enterprise
New Zealand Winegrowers
Noted Ltd
Orion Health
Pāmu Farms of New Zealand

Peter Fraser
Peter McBride
PHARMAC
Plant & Food Research
PlantTech
Riddet Institute
Roger Ford
Rowan Simpson
Serge van Dam
Simplicity (NZ) Ltd
Stephen Knightly
Straker Translations
Synlait
TDB Advisory
Technology Investment Network
The Consortium for Medical Device Technologies
The FoodBowl
The MedTech CoRE
The Treasury
Waitematā District Health Board
Wellsouth
Xero
Zespri