NZIER
NEW ZEALAND INSTITUTE OF ECONOMIC RESEARCH

Scenarios for estimating the future food and fibre workforce

NZIER report to the Ministry for Primary Industries

November 2022

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NZIER was established in 1958.

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Summary of future scenarios

The Ministry for Primary Industries, the Primary Sector Workforce data and Forecasting Working Group and NZIER worked collaboratively on a project to estimate future workforce needs in the food and fibre sectors. Economic modelling was based on three scenarios of the future. This report describes those scenarios, and they are summarised in Table 1.

Table 1 Summary of the three scenarios

Scenarios used as the basis for economic modelling of the future workforce

Scenario	Focus	Drivers/assumptions	What it looks like
1. Business as usual (BAU)	Baseline for the project	The next ten years are like the past 10-20 years Some limits and regulations affect industries Technology adoption occurs but is slow	Moderate growth in some industries, while others contract Export profile remains roughly the same as now
2. Increased use of technology	Increased use of mechanisation, automation and digital technologies in production and processing	Current and near-future technologies are widely adopted Safety, quality and labour savings are driving technology choices Investment capital is available	Highly mechanised and automated sectors with high labour productivity Export profile is affected by supply-side factors
3. Transformed sector	A successful, virtuous cycle of technology, sustainability and responding to consumer demands	Whatever we could do, we do Sustainability and technology are embraced They affect not only how things are done, but also what is done and how output is sold to the world Success breeds success: profits are reinvested in the sector	High-growth sectors with extensive use of technology and extensive understanding of environmental impacts Exports are high-value to discerning markets, with considerable value-add before they leave NZ Brand NZ is on top of the world

Source: NZIER

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1 Purpose of this report

The Ministry for Primary Industries (MPI), in conjunction with the Primary Sector Workforce Data and Forecasting Working Group, engaged NZIER to support the Primary Sector Workforce Programme. NZIER contributed to collaborative work on estimating the size of the current workforce and describing its composition in terms of roles and industries. It also conducted macroeconomic modelling and supplemental analysis to forecast future workforce needs.

To create a forecast of the future workforce, MPI and NZIER developed three scenarios about the future. These scenarios were discussed with representatives of industries and sectors in the food and fibre sectors (listed in Appendix A) and formed the basis for economic modelling. This report describes the scenarios in words and numbers. It complements other work from the project reported separately, including work on current workforce counts, forecasts of the workforce in 2032, and modelling of the economy in these different scenarios.

2 Structure of the portfolio of scenarios

These scenarios have been developed as part of a project on forecasting the future workforce of the food and fibre sectors in New Zealand. Different futures await us, depending on both what we do and drivers outside our control. For policymaking and industry planning, it is more important to develop a range of possible scenarios than to argue over which one is 'best' or 'right'.

The project focused on developing three scenarios for the year 2032, or 12 years from the base year of 2020. Three scenarios are enough to cover several options regarding future sector development but are also manageable and provide clear distinctions among them. The scenarios have some overlap with each other but are not meant to be mutually exclusive predictions of the future.

The future of the food and fibre sectors workforce will be driven by many things, but three sets of drivers for the scenarios are economic, technological and environmental. Economic drivers include investment in plant and equipment, development of new processes, continuous improvement in efficiency, changes in the workforce, skill development and training, land-use change and market changes. For example, the increased use of herd homes or shelters for dairy cows represents an increase in investment for an expected economic payoff. Changes in the workforce can lead to new shift times in processing plants, for example, shifts scheduled around school hours. New overseas markets can lead to changes in production, distribution and exports. These drivers are part of the constantly changing nature of the food and fibre sectors.

Technology also drives change in the food and fibre sectors. For this project, we are particularly interested in the speed of mechanisation and automation. While these terms are sometimes used interchangeably, we can think of mechanisation as replacing specific labour tasks, while automation is more systemic and may include elements of

computerisation, digitisation, or artificial intelligence.[1] For example, a petrol-driven post-hole drill is a mechanical substitute for a post-hole digger and speeds up the job of fencing. Animal collars linked to sensors and networks are automation technology that could replace fences altogether. They can also provide farmers with more information about their animals and, through data analysis, can remotely identify animals that are, for example, injured or calving. New machinery for postharvest handling can increase throughput at packing plants, reducing or changing the role of workers.

Environmental drivers are affecting the food and fibre sectors through production impacts, market impacts, and regulatory changes. Production impacts are the changes to conditions as a result of temperature, weather and water. Regardless of anything else, temperatures are changing, and that will have an impact on things like animal stress, fruit maturity and chilling requirements. In addition, concern about environmental issues is affecting consumer preferences and *private standards*, or the requirements that commercial businesses put on their suppliers. Finally, regulations in New Zealand around water, greenhouse gases, biodiversity and other concerns are changing what can be done, where and when. A recent example is the changes to winter grazing rules, which mandated how much forage crops could be grown on a farm, on which slopes the rules applied, and when pastures had to be re-seeded. Regulations also affect where a processing plant can be located or how businesses deal with processing waste.

The project has developed three scenarios that cut across these three dimensions. These scenarios can be treated as stand-alone visions of the future or can be combined to create more complex forecasts. A summary of the scenarios is as follows:

- Business as usual (BAU) – This BAU scenario is based on current projections of the performance of the food and fibre sectors and the whole New Zealand economy. The projections are informed by trends in the recent past around investment, productivity and technology. It also takes a conservative approach to environmentally-driven changes, extrapolating from the levels of change in the sectors over the past 20 years. The scenario includes some productivity growth and technological change but no major leaps, structural shifts, or market impacts.
- Increased use of technology – This scenario builds on the BAU by considering the potential impacts of greater automation and mechanisation through increased use of technology across the sectors. By reviewing government and industry documents and holding discussions and hui with sector and industry experts, we have identified new technologies throughout the sectors affecting every industry. One uncertainty is how successful each technology can be at a commercial scale. A second uncertainty is the level of adoption, which is driven by their commercial success but also by the willingness of people to invest and the wider social and political context. One example

[1] *Artificial intelligence* (AI) is a term that has a technical meaning but is commonly used with a much broader meaning. Technically, *machine learning* is a computerised process of introducing data to a learning engine or algorithm (an equation) that searches for regularities or patterns. The target (what is being achieved) and the data are controlled by the human operator, but the process is discovered ('learned') by the machine. Computers can assess larger datasets than humans, and can find solutions that are successful but surprising. AI takes this one step further and learns about learning. The problem to be solved and the dataset to use for information may be less well defined or 'fuzzy'. A generalised AI, one that is not context-specific but instead can apply itself to a wide range of problems, does not currently exist and there is debate over whether it ever could.

AI is often used in a broader sense of computer-aided data processing. With more sensors and other input devices available, as well as cheaper memory and more connectivity, more meaning is being extracted from data. Farmers can more readily assess the performance of individual cows, or can more finely decide how to spread fertiliser. Wholesalers can have better, more timely information about what products are selling where. All this information, plus decision support tools, can enable better decision-making.

is the development of aquaculture. The industry depends on water space in suitable locations, which depends on permission from the government and *social licence to operate* (SLO) from affected communities. The industry is working on developing new technologies and is willing to invest, but without permission, it cannot deploy them. In this scenario, the main impacts are productivity shifts in the production and processing industries.

- Transformed sector – This scenario imagines the combined impacts of economic, technological and environmental drivers. Investment money is made available across the industries. New technologies in production and processing are adopted. New market opportunities are developed and exploited: high-value products in new markets with discerning consumers. Environmental bottom lines are achieved and even exceeded, with sectors that contribute to regenerating the natural world and make that effort part of the international identity. The workforce is part of this transformation. Workers with more skills and more training earn competitive incomes, attracting people to careers in the food and fibre sectors.

We have restricted this research to three scenarios to make the work achievable and understandable. The BAU scenario lays the foundation of steady-as-she-goes. The second scenario brings in the impact of technological changes. The third scenario, sector transformation, goes even further to look at market, technological and environmental transformation. The scenarios present contrasting perspectives of the workforce needs for the different paths the food and fibre sectors could take. Another advantage of the scenario approach is that it enables us to understand the different drivers of change and how they impact the workforce, thus providing insights into potential actions.

2.1 Presentation of economic impacts

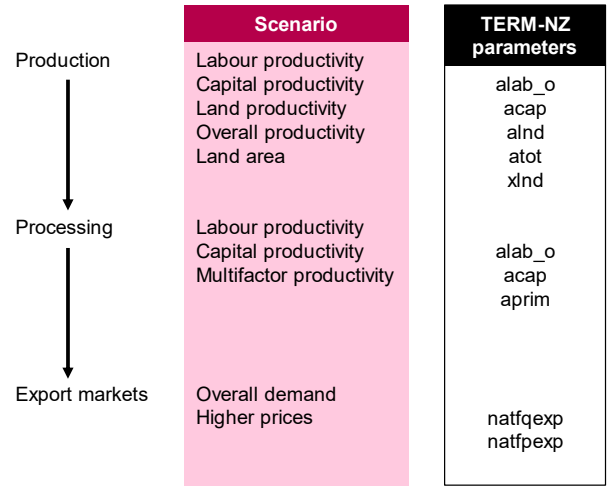
This report is mainly about the information gathered from several sources, including interviews with key informants from industries in the food and fibre sectors. The information is presented for each scenario one at a time. There is a summary, then an overall description, and finally, a description of details by sector and industry.

At the end of each scenario is a table. The table presents the parameters for each scenario. The parameters are the link between this scenario development work and the quantitative economic modelling. The parameters specify the size of impacts and create the change in the modelled economy.

Figure 1 shows how the scenarios are linked to the modelling. On the left-hand side are different stages of the food and fibre sectors supply chain: production, processing and export. They correspond to the core production and core processing industries in the workforce counts, as well as demand for New Zealand exports. In each part of the supply chain, there are economic variables that can be adjusted to reflect each scenario. They are shown in the middle column of Figure 1: labour, capital and land productivity, land area and market variables. The right-hand side of the figure names the specific variables in NZIER's Computable General Equilibrium (CGE) model that could be modified. This is technical information provided for completeness. Additional reporting on the CGE modelling method will be provided. As part of developing the scenarios, we consulted with the Centre of Policy Studies (CoPS) at Victoria University in Melbourne on the appropriate use of these parameters. After discussion and preliminary modelling, we focused on using one

multifactor productivity parameter and one export market parameter for modelling the scenarios.

Figure 1 Approach to modelling the scenarios



Source: NZIER

For each scenario, there is a table of representative values for the multifactor productivity in Figure 1. The values are provided by the production, processing and export stages and for each sector in the project (arable, dairy, etc.). They are meant to provide a sense of the modelled changes relative to the past and each other.

3 Business as usual (BAU) scenario

3.1 Summary narrative of BAU scenario

This scenario extrapolates from past performance to describe the situation in the food and fibre sectors in 2032. It is based on trends in the recent past around investment, productivity and technology. It also takes a conservative approach to environmentally-driven changes, extrapolating from the levels of change in the sectors over the past 20 years. In this regard, the scenario describes an approach to environmental regulation, in which regulations are met but are not used to develop market niches or high-value product offerings. The scenario includes some productivity growth and technological change but no major leaps, structural shifts, or market impacts. No major shifts are foreseen in overseas markets because of changes in consumer behaviours or market access. Core production is based on current trends, with reductions in sheep and beef farming, fairly constant areas in dairying and arable land, and increases in horticulture and forestry. Fishing and aquaculture are also fairly static. In core processing, current trends continue, with some industries changing productivity faster than others.

3.2 The food and fibre sectors in the BAU scenario

The baseline future of the food and fibre sectors is a continuation of recent trends. In terms of land area, we expect an expansion of forestry and wood processing, aquaculture and

arable farming and a reduction of sheep and beef farming, with little change in the area used for dairy. We expect horticulture to expand, probably on former dryland pasture, and peri-urban growth will also take some land out of farming.

Productivity will continue to increase. For core production, productivity gains mean more production per hectare or per animal. These gains may be the same steady gain through management and genetics we have seen for decades. Other industries appear to be in the middle of a step change; horticulture and the shift to 2D orchards is a key example. For core processing, a slow but steady increase in productivity is also expected. One issue is that the impact of digital technologies on supply chains and traceability is uncertain. There have been efficiency gains, and more could be made, but how the technology will develop and produce economic gains is uncertain.

The final driver of output is the value per unit. All industries are targeting higher value per unit. Some are looking to digital technology to help inform distributors, retailers and consumers and extract a premium through better information. Others are planning to target specific, high-value consumer segments with messages about environmental friendliness, product safety, or New Zealand or Māori values. A third approach is product development: creating new products or new variations that respond to overseas consumer segments.

The combination of changes in land use and higher productivity will result in all industries producing at least as much as they do now, if not more. Add to that the increased value per unit, and every industry is planning on economic growth.

The resulting environmental impacts are uncertain. Plans to expand and intensify production imply higher impacts on water and climate (as well as biodiversity) unless conscious steps are taken to reduce them. Economic conditions will influence the rate of reductions and technology and management techniques. Pressure on water quality in specific catchments will likely lead to a combination of management changes and land-use changes, but the impacts would be localised.

Legislation has now been introduced to mandate Farm Environmental Plans (FEPs), but the practical impacts on farming practices and the environment will take some time to have an impact. Time will be required to create policies, develop advisory capabilities in the sectors, and roll out regulations and practices for FEPs, and plans are forward-looking, so environmental impacts will lag plans.

The environment will continue to change. More floods and droughts are expected, as well as changes in temperatures and chilling that will affect production as well as the volatility in production. Short-term and long-term responses to those events and changes will require capital investment, taking funding away from other types of investment in the sectors (such as product development and technology).

The social and cultural aspects of the food and fibre sectors are changing. Some sectors, such as the Red Meat and Wool sector, are facing an ageing workforce, urban drift is continuing, and there is increased competition for labour and skills. While location and the demands of biological production will continue to significantly influence work within the food and fibre sectors, technology and changing business models will have an impact. For example, as forestry harvesting becomes more mechanised and requires more training and experience, forestry workers are likely to have better pay and working conditions. Likewise, as platforms become more prevalent in the apple industry, some roles will become less

physically demanding. All this signals the importance of investing in great workplaces, including upskilling and career progression.

The reputation and perception of the food and fibre sectors in the wider society will follow these other trends. Environmental and social impacts will influence those perceptions, possibly more than any economic contribution from the sectors. To the extent that environmental impacts are reduced, and working conditions are improved, social perceptions are likely to improve. If current tensions in New Zealand are exacerbated, both from environmental consequences of climate change and from social divisions resulting from economic inequality, and the food and fibre sectors is seen as 'part of the problem', then its social perception will suffer.

Māori – as individuals and as organised entities – are likely to have greater influence in the sectors and represent a larger portion of assets and the workforce. Iwi entities are taking more control over their productive assets and giving more direction to the sectors. They will continue to push more into higher-value industries and away from low-value land uses. New supply chains and commercial relationships will be developed.

These activities in production, processing, marketing and distribution will provide more opportunities for employment. In addition, there will be more Māori with tertiary qualifications and professional experience taking more management and leadership roles in the sectors. Crown-Māori relationships will continue to evolve, but this will take time.

The workforce overall will be more productive. It will have many of the same features as today: similar seasonal patterns and splits between full-year and part-year work. Some work will become less physical, and some tasks replaced by machines and technology. Some work will become more complex, especially for managers and owner-operators, and especially if advanced technology is used and greater information is available to help drive productivity and quality. They are likely to require higher levels of education and training to remain successful. These developments will also likely create more specialised roles for advisors and contractors.

3.3 Recent productivity changes

Table 2 provides a background to this discussion. The figures in the table are organised according to the information from Stats NZ, and the annual change figures from 2008 to 2021 are as reported by Stats NZ.[2] The annual change figures indicate that productivity changes have varied by industry and by type of productivity. Agriculture, for example, has had the highest growth in labour productivity, while wood and paper products manufacturing has had the highest growth in capital and multifactor productivity. Food, beverage, and tobacco product manufacturing has had reduced productivity over the period. The reduction means that output per unit of input has fallen: the industry is less productive or efficient.

[2] Stats NZ. (2022). Productivity statistics 1978-2021: productivity by industry, corrected. Wellington, 06 May. https://www.stats.govt.nz/information-releases/productivity-statistics-1978-2021

Table 2 Productivity changes, 2008–2021

Measured changes in the New Zealand economy

Productivity type	Annual change (%)
Agriculture	
Labour	2.8
Capital	1.6
Multi-factor	1.5
Forestry, fishing, and services to agriculture, forestry, and fishing	
Labour	1.6
Capital	0.5
Multi-factor	1.0
Food, beverage, and tobacco product manufacturing	
Labour	- 0.4
Capital	- 0.5
Multi-factor	- 0.5
Wood and paper products manufacturing	
Labour	1.7
Capital	3.6
Multi-factor	2.3

Source: Stats NZ, NZIER

3.4 Sector detail for the BAU scenario

The future of the workforce in the food fibre sectors will vary by sector. The details below are based on industry documents and discussions with key informants.

Arable

The production and processing workforce is expected to be stable, but the sector is expected to grow somewhat, becoming more highly mechanised. There are potential gains from the increased use of precision agriculture and sensors. The arable sector could also be affected by changes in the dairy sector, which may want to source increasing amounts of bought-in feed. There is tension between the forces of globalisation and localisation. Globalisation can help the arable sector become more integrated into international value chains and connected to trends and technologies. However, the Russian invasion of Ukraine and subsequent disruption of global grain supplies have highlighted the risks of depending on imported foodstuffs, and many countries are reviewing their food security.

Dairy

The development of the dairy sector will be influenced by political and market factors. The sector is engaging with the government on plans for reducing the climate impact of dairy farming. The sector is also interested in greater overseas market access, which can be influenced by government involvement in trade discussions.

The number of workers overall will remain relatively static. Physical jobs will remain; mechanisation will not remove them from production. Management jobs will become more complex, and a new management level will emerge either as employees, contractors or expert advisors. The optimal size of farms is likely to increase with greater returns to management skills. Processing will continue to evolve, making steady productivity gains, and the product mix will remain similar to today's.

Forestry and Wood Processing

The research and discussions conducted to develop these scenarios identified expectations that the workforce would shrink somewhat and become more highly trained, both in production and processing. Greater productivity of forests will increase harvests, but that growth is likely to be more than offset by mechanisation. Processing will continue at its current levels unless joint government-industry plans increase processing capacity.

Horticulture

Workforce needs are difficult to predict. Across the different crops, greater production and land area should increase the demand for workers, while system changes and automation/mechanisation are reducing the workforce requirements. Greater education and training are expected for management roles because of both technology and greater environmental regulation. Horticulture is also a part of the food and fibre sectors that could grow high-value products from a small land base, increasing New Zealand's exports. The sector is also affected by wider issues, such as climate change legislation and the loss of high-quality land to housing development.

Kiwifruit

Kiwifruit may see packhouse changes, but on-orchard changes are likely to be smaller. The industry will benefit from new cultivars, but planting areas may be intentionally limited. The biggest changes in productivity are likely to be in the packhouse. Volumes may increase somewhat because of new cultivars and improved management. There is uncertainty because of the review of Hi-Cane and the potential for its use to be restricted or discontinued. The industry is working to improve working conditions and is also aware of the risks around social licence to operate (SLO). SLO refers to the social acceptability of practices and non-market pressures, e.g., social media campaigns, that can arise to change practices.

Apple and pear growing

Pipfruit is likely to see continued growth of high-value markets and cultivars, e.g. Envy, plus increased technology in packhouses and potentially more technology in orchards. For example, Turners & Growers has invested $100 million in new packhouse facilities. The industry is interested in more free trade agreements and increasing market access, particularly in diversifying markets to reduce risk. The industry is also addressing workforce issues, such as the social environments the workforce comes from and working conditions.

Viticulture and winemaking

An important context is that the wine industry has doubled the value of exports over the past 10 years. Area in vineyards is expected to grow about one percent per year for the next several years, but after that could slow. There are likely to be small technological changes in vineyards and in winemaking. Vineyards are limited in productivity gains because much of the harvest is already mechanised, and vine pruning needs to be done by hand. Winemaking is limited in productivity gain because much of what can be mechanised

has been, and gains from scale are already achieved by using contract facilities and logistics suppliers (e.g. WineWorks in Marlborough and VinPro in Central Otago).

Pork, Poultry, Bees and Other

The industries in this group all expect low growth because of some limiting factor. The pork industry has a domestic focus and competes with low-cost imports. It is likely to maintain its current market share but is unlikely to out-compete overseas producers. The poultry industry appears stable in terms of technology and markets. There could be some opportunity to expand by making the most of New Zealand's lack of key poultry diseases, but this scenario assumes that doesn't happen. Manuka honey production also looks to be stable in terms of production technology and markets. Much of the work of managing hives and extracting honey is labour-intensive, but there are few options. There could be increases in the scale of processing, but the industry's current structure with many small producers makes this unlikely.

Red Meat and Wool

Our research on the sector and discussions with sector experts indicated that the sector expects production to shrink and the workforce with it. Farming units will continue to be largely owner-operated, although more consulting and extension may emerge. Processing is likely to be more automated and safer, with automation driving a further decrease in the workforce. The value of the wool clip is up for debate, with a low current price but potential innovations on the horizon. The sector is working on climate issues. We generally expect processing technology to keep pace with the past, which has seen low productivity growth in manufacturing industries, including meat processing.

Seafood

The future of the seafood sector will be affected by several issues. For fishing, quotas do not allow expansion of the quantity of the catch, so either the industry will be fairly static, or it will move toward greater processing and value-add. Aquaculture will need to contend with policy decisions and the impacts of climate change. Production space is a complex issue: the industry would like more space or different locations but also has consented space that is not currently used for production. The industry could also use some existing farms more intensively. For this scenario, we consider that these industries will have little change, with some productivity improvements.

3.5 CGE model parameters for the BAU scenario

Table 3 provides a table of values for the changes to be modelled for this scenario for all the industries. The figures take into account the baseline changes in productivity in the past, the descriptions of the industries above, and forecasts from MPI reported in the Situation and Outlook for the Primary Industries (SOPI). Industry representatives have provided feedback on the figures in the table, as well.

Table 3 Modelled changes in the economy, BAU scenario

Parameter changes applied to TERM-NZ

Sector	Core production productivity increase	Core processing productivity increase	Export demand increase
Arable	27%	1%	10%
Dairy	0%	0%	10%
Forestry and Wood Processing	27%	1%	10%
Horticulture	27%	1%	42%[3]
Pork, Poultry, Bees and Other	27%	1%	10%
Red Meat and Wool	27%	1%	10%
Seafood	27%	1%	10%

Source: NZIER

4 Increased use of technology scenario

4.1 Summary narrative of the increased use of technology scenario

This scenario envisions a food and fibre sectors that maximises existing and emerging technologies. Potential changes generally involve mechanisation, automation or greater use of digital and information technologies. In core production industries, there is scope for replacing human labour in some tasks or in assisting workers with physical tasks to increase output. However, the nature of tasks and the environment – the variability in plants, animals and terrain and working conditions such as dust, heat and rain – limit the use of machines. Core processing industries often have greater potential for labour-saving technologies and returns to scale. However, some processing industries are already highly mechanised or automated, limiting the potential for future technological change. The strongly connected industries are a mix in terms of the use of technology. One key area is the use of data, analytics and information. By collecting more and better data, analysing it with greater speed and precision, and sharing the information with suppliers and customers, food and fibre sectors may be able to increase the quantity or the value of production or reduce costs. This scenario is an attempt to summarise these changes by sector and forecast potential growth from a high uptake of technology.

4.2 The food and fibre sectors in this scenario

For this scenario, there is a range of technologies that could be adopted. Mechanisation focuses on replacing manual or human tasks with machinery; an example might be motorised orchard harvest platforms. Automation is more extensive; rather than a one-for-one replacement, it aims to change processes to make the most of technology. Digitisation focuses on flows of information. Making information digital (computerised) makes it available for analysis, search and communication. For example, information on irrigation, fertilisers and yields can be analysed in fine detail over a farm or paddock in areas of poor

[3] The export shock for viticulture and winemaking is 10 percent, based on discussions with the industry and the Situation and Outlook for the Primary Industries (SOPI) from June 2022.

production, which can then support better decision-making to improve productivity. Digital information is also more easily shared. By using websites or digital platforms, distributors and consumers can access more information about food products production and processing.

These technologies tend to focus on production and efficiency and can have both economic and environmental impacts. They may increase the yield per hectare for an orchard or reduce the time required to handle livestock. They can also provide more information to make it easy to meet regulations or inform government agencies about compliance. They can reduce management effort by automating actions or sending alarms when something breaks. The impacts on land productivity tend to be clear: they increase output per unit of land. (A key exception is situations in which they allow farmers to identify locations that would be better as buffer areas or environmental set-asides.) The impacts on labour productivity also tend to be clear. On farms and in processing industries, technology tends to be labour-saving, increasing labour productivity. The effect on capital productivity is less clear. Generally, new technology requires investment, which then requires a return on investment. Whether the lift in productivity is greater than the investment is an empirical question: it depends on the industry and technology. For this scenario, we will assume that investment improves capital productivity, but we need to signal the ambiguous nature of investment.

Our own research and discussions with industry members has made one thing clear: the story is in the details. There is no blanket assessment that we can make about the food and fibre sectors, or about all core production industries or all core processing industries. Each one is working on its own problems and opportunities and its particular markets, which technology is looking to solve in particular ways. Mechanised harvesting is a good example. Grapes for wine can easily be harvested by machine, while cherries for export markets require a human touch. But, although grapes can be machine-harvesting, vines still need to be pruned by hand. Furthermore, some wine producers will continue to harvest by hand because they can receive a premium for producing and selling wine marketed as being from hand-harvested grapes. Another issue is the extent of existing automation. Milk dryers, for example, are already highly automated, which gives dairy processing less room for more automation at that part of the processing system.

4.3 Sector detail for increased use of technology scenario

Arable

Arable is expecting more automation and the use of information technology in the near future. Precision agriculture techniques and equipment have been under development for decades and are widely available commercially. New digital technology is providing more information and greater control, as well as more networking of information and people. There is potential for large gains in land and labour productivity in core production. In core processing, it is less clear what the gains could be.

Dairy

Dairy has a history of more investment and changes in technology, in both core production and core processing. It is unclear how much this might accelerate; it could be that gains will continue at the pace of the last couple of decades. Increases in the scale of farming operations could lead to gains in labour productivity: workers could be handling more

animals and using more automation and digital information technologies. The sector has indicated that it is interested in leveraging the benefits of new digital technologies, and sees data connectivity and decision-making support as areas of potential benefit. In processing, processes are already highly mechanised or automated, so there is limited scope to increase labour productivity.

Industry reports that there is $160 million invested annually in research and development, part of which is on digitisation, which is likely to increase productivity. The processing industry is also in the midst of transforming its energy use, changing the source of energy for its process heat needs and moving towards electric and hydrogen-powered vehicles.

Forestry and Wood Processing

There is a vision for the sector in which technology is used throughout core production and core processing to create more value and greater productivity. Automation, robotics, sensors and data analysis could all combine to allow the sector to produce considerably more output with a smaller workforce. There is also interest in producing more processed products. Biofuels, bioplastics, and a greater variety of processed and engineered products are also possible.

Horticulture

Horticultural industries all seem to have scope for increased technology, but the specific changes vary by industry. Mechanised harvesting, automated harvesting and new growing approaches (2-D, containment) can all change on-orchard production. In core processing, several industries are in the process of making large investments to improve cleaning, sorting and packing.

Kiwifruit

The industry is focused on creating efficient supply chains that are digitally enabled or even digitally transformed. The driver for this work is assuring overseas markets about quality and safety and verifying product origin in the face of food fraud. The biggest impact of mechanisation is expected to be in the packhouse.

Apple and pear growing

The pipfruit industry continues to focus on trademarked and protected cultivars produced in environmentally sensitive ways for high-value markets. Technology is an enabler all through production, processing and distribution. One trend is for higher production per hectare, while a second trend is great labour productivity through technology. Whether the total labour requirement rises or falls depends on the relative impact of the two trends.

Viticulture and winemaking

The industry sees labour supply as a major issue and has a vision of a diverse, future-focused workforce and being an industry of choice for workers. The Bragato Research Institute is a major supplier of technology research for the industry. The industry is also focused on environmental issues and targeting quality rather than quantity of output. The role of technology – the focus of the scenario – is unclear given these areas of focus.

Red Meat and Wool

The sector is working on science and innovation to promote sustainability and productivity. One area of work is in core processing, where the sector is trying to create safer, more productive workplaces. Digital technology will help the sector tell its story about where the

meat comes from and how it is produced while maintaining the traceability of the product all the way to the consumer.

Wool as a product is looking to technology to revive its fortunes. A number of technologies or innovations are being developed to lift the value of strong wool. They provide the possibility that new uses for wool can raise productivity in the industry.

Seafood

Fishing and aquaculture are both industries with the potential to increase technology. They have constraints to production – quotas and water space – that make returns to investment in technology less certain. On the other hand, aquaculture has been identified as an important growth industry by the industry and the government. The main technology challenges in aquaculture are: improving the use of spat, successful blue water or open water farms, and land-based aquaculture. Across seafood, increased processing and product development have the potential to increase the value-add of the industry and thereby lift productivity.

4.4 CGE model parameters for increased use of technology scenario

Table 4 provides values for the changes to be modelled for this scenario. They build on the BAU future scenario and focus on increased productivity across the sectors. They are based on past data, review of industry information and discussion with industry representatives.

Table 4 Modelled changes in the economy, increased use of technology scenario

Parameter changes applied to TERM-NZ

Sector	Core production productivity increase	Core processing productivity increase	Export demand increase
Arable	37%	11%	20%
Dairy	0%	0%	10%
Forestry and Wood Processing	37%	21%	10%
Horticulture[4]	37%	11%	42%
Pork, Poultry, Bees and Other	37%	11%	10%
Red Meat and Wool	37%	1%	10%
Seafood	27%	11%	10%

Source: NZIER

[4] Under this scenario, the following industry-level changes are modelled within the horticulture sector:

- for kiwifruit: core production – 32 percent, core processing – 11 percent, export demand – 42 percent
- for viticulture and winemaking: core production – 37 percent, core processing – 6 percent, export demand - 10 percent.

5 Transformed sector scenario

5.1 Summary narrative of the transformed sector scenario

The transformed sector scenario builds on the increased use of technology scenario and adds a concern for sustainability and focus on high-value products and markets. The concern for sustainability is based on the Māori concept of Te Taiao, so it encompasses not just the natural environment but also people and their relationships. The workforce and its wellbeing are thus part of Te Taiao and the scenario, as are greenhouse gas reduction and improving freshwater health.

In the transformed sector scenario, increased investment in people and the environment is possible because of the sectors focus on high-value products to high-value markets. Research and experience have demonstrated that producers can achieve premiums for products that can make credible claims for sustainability. They have also shown that moving away from simple commodities to more processed products can move the sectors down the value chain and capture more of the consumer's spending. Done right, marketing and product development can generate the returns necessary to invest more in people, plant and equipment, and the environment. The scenario is about a virtuous cycle of success and improvement.

5.2 The food and fibre sectors in this scenario

In the transformed sector scenario, we build on the assumptions/results from the increased use of technology in the previous scenario and add a greater concern for sustainability. We focus on high-value products and markets in this scenario and ask:

- What if industry and government growth aspirations are met. What will the workforce required to meet those aspirations?
- What if productivity grows faster or slower and what that means for workforces in different sectors.

Our transformational scenario is ambitious. If the aspirations within this scenario are achieved, then this will result in a story where investment in people and the environment increases, and the sector transformation is reflected through an increased focus on high-value products for high-value markets. Research and experience have demonstrated that premiums can be achieved for products that can make credible claims for sustainability. They have also shown that moving away from simple commodities to more processed products can move the sector down the value chain and capture more of the consumer's spending

We already capture the aim of greater productivity through increased use of technology scenario. Sector transformation, therefore, adds three elements to the previous scenario:

- Greater returns through greater value-add. Throughout all the scenarios, there is an expectation that part of the development of the food and fibre sectors is increasing export revenues by increasing the value added to products in New Zealand.
- Putting sustainability at the heart of decisions. Again, all the scenarios have some element of a sustainability focus. One use of technology is enabling greater

sustainability through changing production processes or improving information and management. However, in the transformed sector scenario, sustainability is at the heart, and the food and fibre sectors learn how to translate a sustainability focus into greater economic returns.

- Growing the workforce is a goal. In the first two scenarios, the size of the workforce is an outcome of other drivers. Markets and technology are driving those scenarios, resulting in some level of employment in the food and fibre sectors. In the transformed sector scenario, there is an explicit focus on increasing employment in the sectors. In addition, putting workforce growth alongside a focus on Te Taiao and sustainability means that the aim is better working conditions and career paths for people in the sectors.

In developing this scenario, we have thought of it as doing and getting everything right. This scenario imagines food and fibre sectors and a country where a focus on wellbeing, sustainability, technology and productivity creates excellent working conditions that create excellent products in high demand by discerning overseas consumers. In the transformed sectors, this approach also makes economic sense: the premiums achieved in overseas markets create material wealth for businesses and the workforce in the sectors.

5.3 Sector detail for transformed sector scenario

Arable

The arable sector is already expecting expansion because new technologies can improve production and returns. Precision agriculture – a combination of automation and digitisation – can increase the efficiency of input use and production per hectare. Sustainability concerns have the potential to drive arable expansion further. First, high-efficiency arable farming limiting greenhouse gases and nutrient loss, is a potential replacement for other land use. Second, demand for animal feed other than palm kernel expeller (PKE) may increase demand for grains.

There is research and development in the sector looking for ways to create higher-value products, such as oat milk or alternative proteins. The economics of these products isn't clear – our research has found supporters and sceptics. However, it is clear that there is interest in finding more uses for the products of arable farming.

Although there is a limit to the area in New Zealand that can be cropped, the arable sector is likely to see strong growth.

Dairy

The future of the dairy sector is uncertain under the environmental focus of this scenario. There is already talk of 'peak cow' numbers in New Zealand, that the number of cows cannot grow, and new areas cannot be converted. The sector has a goal of promoting the unique value proposition of New Zealand milk.

Forestry and Wood Processing

As with the increased use of technology scenario, there is a focus on increasing the existing capacity for processed wood products and moving into new products. There is also a focus on forestry – both exotic and native – as a tool for sustainability of the whole food and fibre sectors, and the possibility of using improved environmental credentials for marketing products overseas.

Horticulture

Major horticultural industries, such as kiwifruit, apple and pear growing, and viticulture and winemaking, are already sold to the world based in part on clean, environmentally friendly production methods. The apple and pear growing industry has made concerted efforts for years to reduce agrichemical residues on fruit and target high-value markets. Sustainable Winegrowing New Zealand (SWNZ) has supported organics, biodynamics and regenerative methods. This scenario is about pushing these methods and communicating about them to their full extent. In this regard, this scenario fits well with where some of these industries already want to go: reinforcing positive environmental images and credentials and turning them into commercial advantages in markets.

Red Meat and Wool

The Red Meat and Wool sector has three strategic priorities: market position, innovation and sustainability. In this scenario, the industry can align those priorities to reinforce each other and support a vibrant and profitable sector. Innovation provides tools for sustainability in core production and improvements in core processing. Those improvements and the ability to communicate about them through digital technologies improve the sector's market position compared to other countries. With increased sales and profitability, more money is available to invest in the sector.

For meat and wool, this scenario imagines a future in which the natural, sustainable story of the products lifts their economic performance. New Zealand meat can compete with feedlot meat and alternative proteins because the sector tells its story about healthy animals producing simple, natural food in healthy environments. Wool can gain against synthetics because it is a natural choice; it isn't petrochemical extrusions that break off and pollute pristine coral reefs and Antarctic ice. In the background, the story of carbon capture in well-managed pastures provides a good-news climate story.

Seafood

In this scenario, seafood from fishing and aquaculture is able to use naturalness and sustainability to extract more commercial value. For fishing, in particular, a limited catch is turned into high-value products with a marketing story about isolated Pacific stocks sensitively managed by a caring industry. It also turns the wild catch into a marketing advantage against increasing amounts of farmed fish: the authentic taste of fish the way they were meant to be. Aquaculture also finds its story, perhaps of well-managed finfish, mussels and oyster farms in cool, clear waters at the bottom of the world. The products sold to consumers are tasty and convenient, keeping up with food trends. Behind these stories, real actions are managing wild fish stocks at sustainable levels and sharing both risks and fish supplies. Aquaculture is using technology to create, monitor and maintain low-impact farms and proactively shares data on its environmental performance with supply chains and customers.

5.4 CGE model parameters for transformed sector scenario

Table 5 provides values for the changes to be modelled for the scenario. They incorporate the changes from the increased use of technology and add better performance in export markets. They are meant to reflect the aspirations of Fit For a Better World and industry strategies that have similar aspirations. They are based on past data, review of industry

information, review of MPI documents and discussion with industry and Ministry representatives.

Table 5 Modelled changes in the economy, transformed sector scenario

Parameter changes applied to TERM-NZ

Sector	Core production productivity increase	Core processing productivity increase	Export demand increase
Arable	37%	11%	30%
Dairy	0%	0%	20%
Forestry and Wood Processing	37%	21%	30%
Horticulture[5]	37%	11%	42%
Pork, Poultry, Bees and Other	37%	11%	20%
Red Meat and Wool	37%	1%	50%
Seafood	27%	11%	20%

Source: NZIER

[5] Under this scenario, the following industry-level changes are modelled within the horticulture sector:

- for kiwifruit: core production – 32 percent, core processing – 11 percent, export demand – 42 percent
- for viticulture and winemaking: core production – 37 percent, core processing – 6 percent, export demand – 30 percent.

Appendix A Individuals consulted during project

John Ballingall, NZ Wine

Derek Bartlett, Elanco

Jay Bocock, Te Awanui (Maori Economic Development)

Michael Brooks, Poultry Industry Association of NZ

Nicola Crennan, NZ Wine

Grant Edwards, PGG Wrightson Ltd

David Evison, Forestry and Wood Processing Workforce Council & University of Canterbury

Jo Finer, New Zealand Institute of Primary Industry Management

Phil Holden, New Zealand Shearing Contractors Association

Alex Huffadine, Summerfruit NZ

Kate Longman, Horticulture NZ

Maitland Manning, New Zealand Pork

Tracey Mansfield, Summerfruit NZ

Georgia Monks, New Zealand Kiwifruit Growers Inc.

Mike Murphy, New Zealand Kiwifruit Growers Inc.

Callum Neil, Beef & Lamb NZ

Tatyana Protsenko, Meat Industry Association

Erin Simpson, New Zealand Apples & Pears Inc.

Gavin Stagg, New Zealand Kiwifruit Growers Inc.

Alison Stewart, Foundation for Arable Research

Geoff Taylor, DairyNZ

Mike Turk, Turk's Poultry

Cathy Webb, Seafood NZ